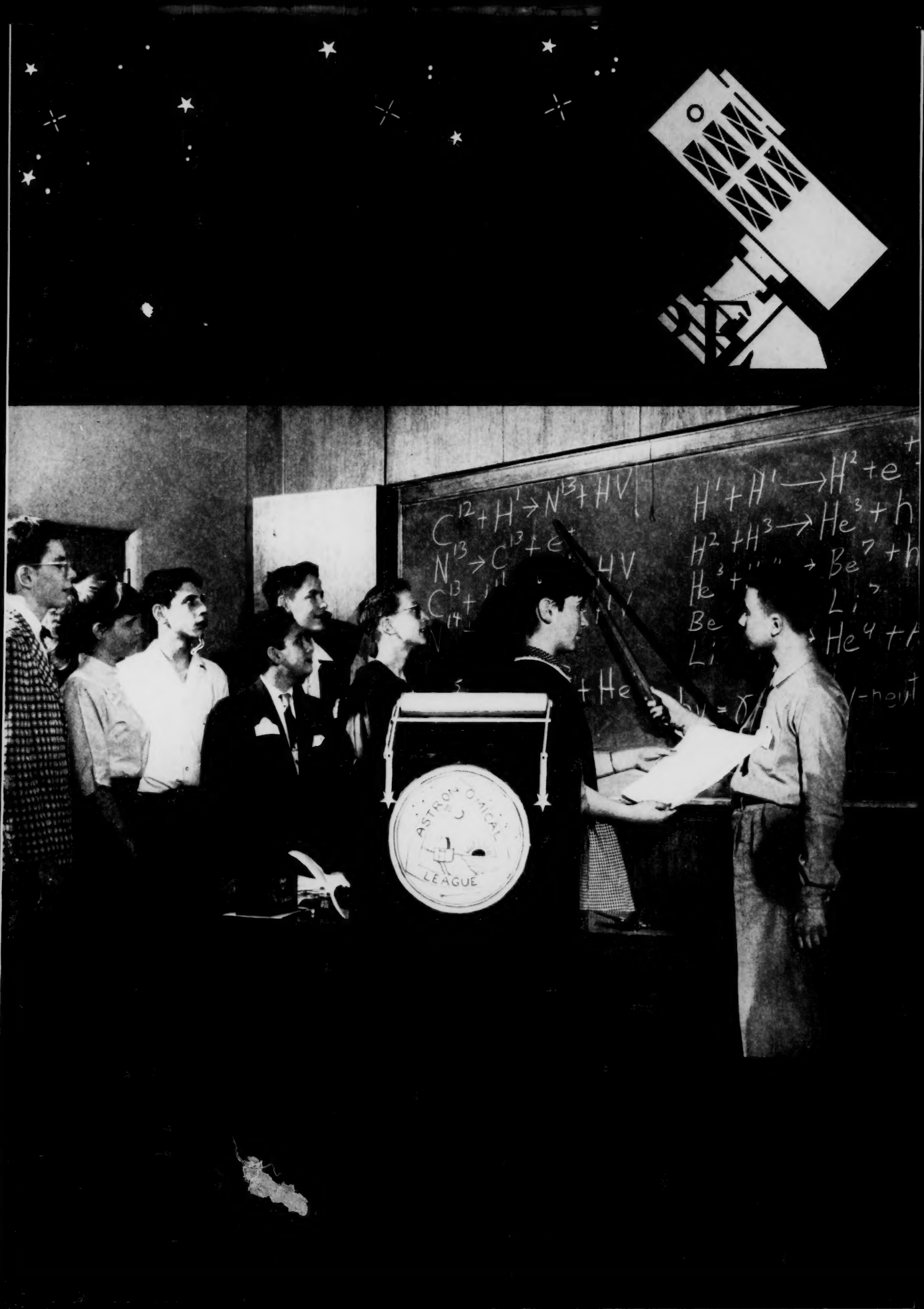
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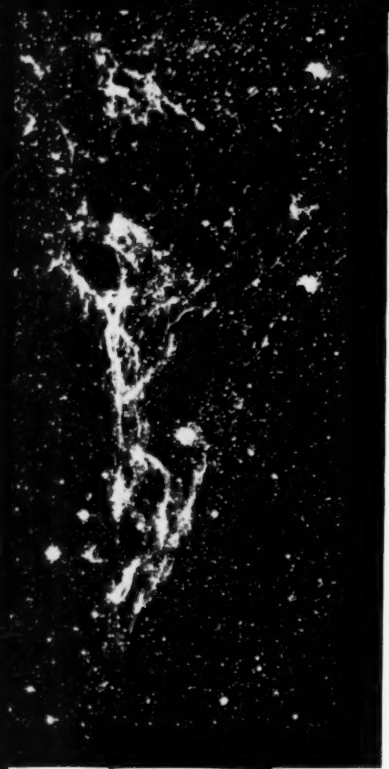

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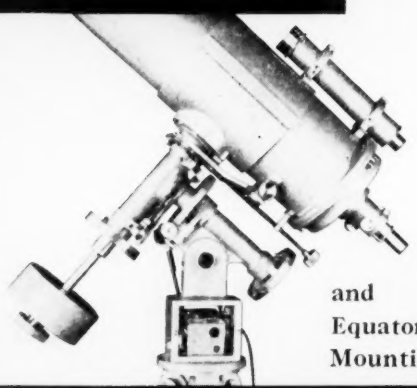

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Sky and TELESCOPE

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The principal articles are indexed in THE READERS' GUIDE TO PERIODICAL LITERATURE.

More Satellite Notes

ARMAND SPITZ, inventor of the Spitz planetarium, has been appointed co-ordinator of visual observations of the artificial satellite, to work with Dr. J. A. Hynek, of the Smithsonian Astrophysical Observatory. As announced on page 203 of the March issue, Dr. Hynek is associate director of the Smithsonian's optical satellite-tracking project.

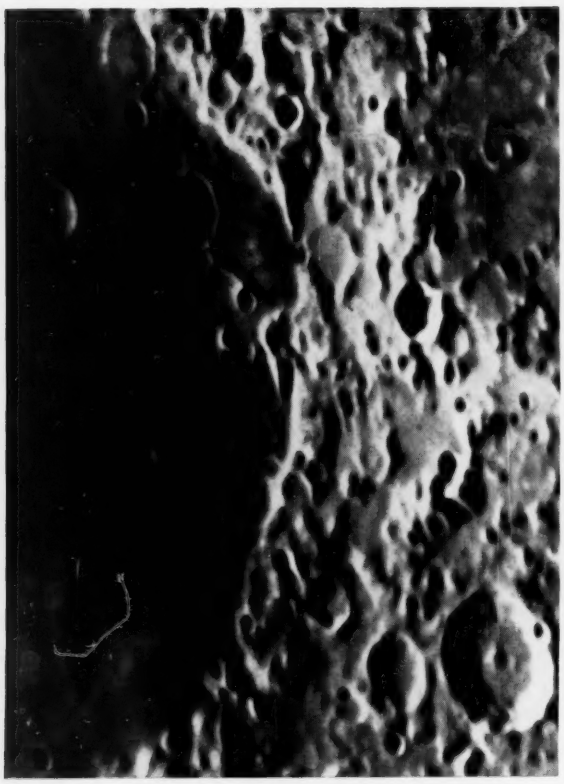
On February 26th, Mr. Spitz met with a group of leading amateur astronomers at Dickinson College, Carlisle, Pa. The committee of the Astronomical League mentioned last month is forming the nucleus of a national advisory committee for visual observations, with the following members:

G. R. Wright, chairman, 202 Piping Rock Drive, Silver Spring, Md.
Thomas A. Cragg, 246 W. Beach Ave., Inglewood 3, Calif.
Walter H. Haas, 1203 N. Alameda Blvd., Las Cruces, N. M.
Edward A. Halbach, 2971 S. 52nd St., Milwaukee 14, Wisc.
Rolland R. LaPelle, R. D. 3, Meadville, Pa.
Charles H. LeRoy, 621 Saxonburg Rd., Pittsburgh 15, Pa.
Russell C. Maag, 904 S. Ohio, Sedalia, Mo.
Margaret W. Mayall, 4 Brattle St., Cambridge 38, Mass.
Grace C. Scholz, 410 Mason Hall Apts., Alexandria, Va.
Steadman Thompson, 1282 Edgehill Rd., Columbus 8, Ohio
Clyde Tombaugh, 636 S. Alameda Blvd., Las Cruces, N. M.

This committee will enlist volunteers and disseminate observing bulletins. Interested amateur astronomers may apply for this work by writing to any of the individual members of the committee. No decision has been made concerning the number or locations of observing sites that will form the Smithsonian network. This cannot be done until the volunteers have been screened and formed into teams.

Mr. Spitz stated that the opportunity for amateurs to make a scientific contribution is very substantial. But the necessary preparation for the observations, the development of observing skills and operational procedure, all need continued enthusiasm for an extended period. The observers must maintain the program over months and perhaps years, so that those with experience in long-range projects, such as sunspots and variable stars, will be particularly valuable for the satellite work.

The Smithsonian Astrophysical Observatory is preparing a preliminary bulletin describing observing problems for the first artificial satellite, to be launched sometime during the 1957-58 International Geophysical Year. The bulletin will also outline the procedures for establishing the observing network.



This portion of Mare Crisium has been enlarged from the photograph opposite to show where the lunar bridge was thought to be located. The spot is centered about $1\frac{3}{8}$ inches from the top of the picture. To the left of it is the formation the author suggests resembles a flying eagle. Lick Observatory photo.

Illusions That Trap Lunar Observers

LELAND S. COPELAND

WHEN eager amateurs scan the moon, interpretative imagination stands by to aid their limited vision. Rarely is seeing at its best, and the wish to find still more is ever present. So the mind tries to extend the reach of eyes and telescopes beyond the seen into the unobserved, or to overvalue the meaning of objects glimpsed. Such recurrent experiences recall Hamlet's crafty remarks about a cloud.

The prince comments that it looks like a camel, and Polonius replies, "'Tis like a camel, indeed." When Hamlet ventures to say, "It is like a weasel," the lord chamberlain concedes, "Backed like a weasel." Next a whale is suggested, and the response is, "Very like a whale."

In a similar way, imagination plays Hamlet while observers peer at small or dim details on the moon or the planets, just as it supplies lines to make the Big Dipper out of seven bright stars. This assistance may be trustworthy and useful. "psychological awareness in spotting sky oddities," as it is described by an amateur stargazer of Greeley, Colo., Dr. J. R. Otoupalik. But it also may beguile night watchers with fantasies that others confidently and happily will accept and defend for many years.

There is real danger that sky hunters, in their pardonable enthusiasm, will surmise more than a cool recheck will corroborate, since, in Shakespeare's words, "such tricks hath strong imagination." Even the ablest men may be deceived; in fact, Sir William Herschel once thought that the resplendent lunar crater Aristarchus was an active volcano.

Changes in the angles of illumination and observation alter the appearance of lunar scenery somewhat as a kaleidoscope redesigns its patterns. Mountain walls that tower tonight may appear insignificant tomorrow. Small craters that dot floors of larger rings under one illumination may be absent under others. Long clefts, clearly marked at times, vanish with the shifting of light and shadow. A further complication comes from handicaps in the earth's atmosphere—air currents, dust, mist, wisps and veils of cloud. Obscure or unsteady seeing has a major influence on the aspect of lunar detail.

Is it surprising, then, that so many dubious things have been seen on the moon? Among the oddities reported are snow, hoarfrost, vanishing craterlets and light streaks, gray or black areas of vegetation, and shadowy masses of moving animals. Most of these must have been fancies, evoked by imperfect viewing.

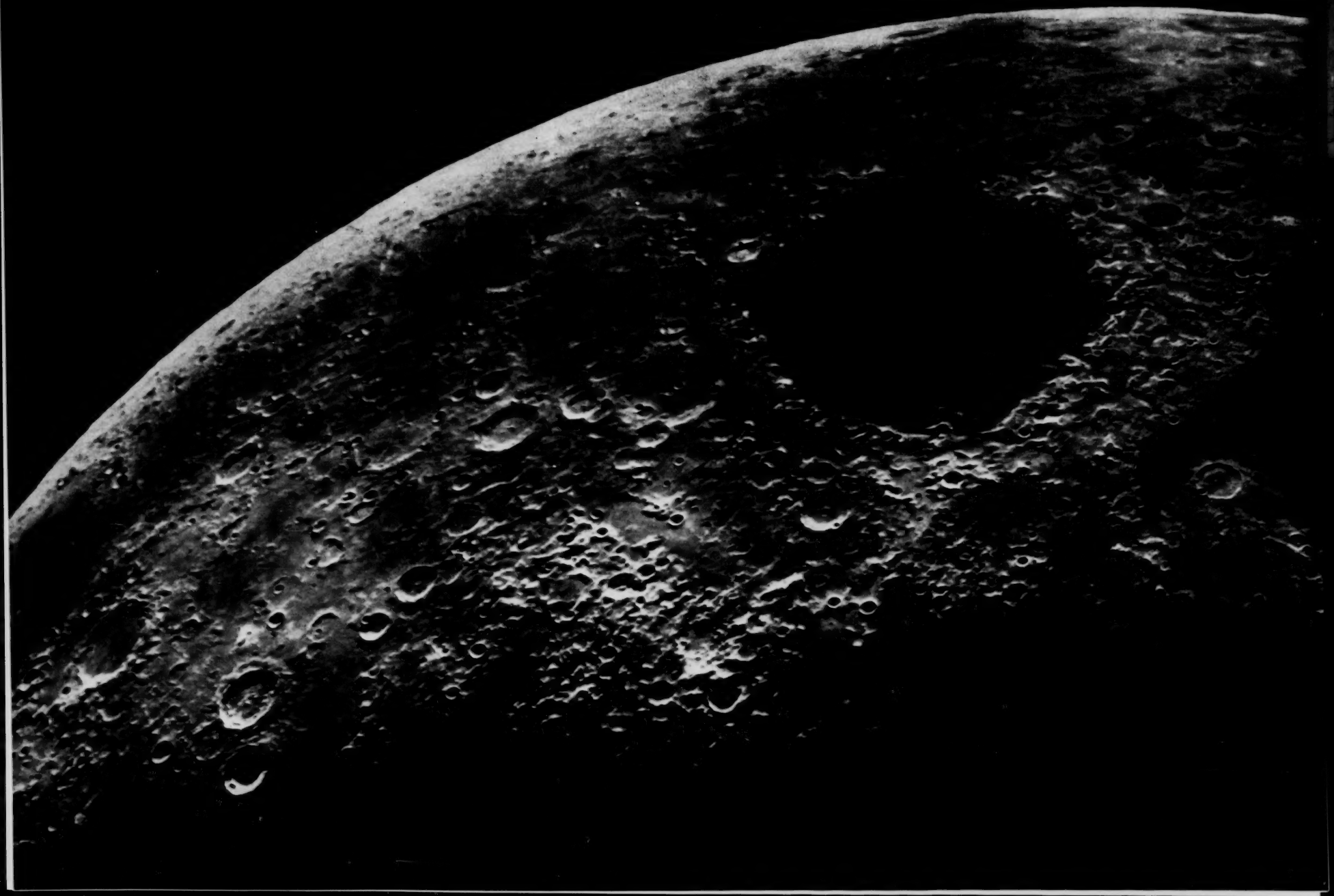
A recent illusion was John J. O'Neill's natural bridge (see the April, 1954, issue, page 205). In the eastern wall of Mare Crisium there is a mountain gate between headlands, Promontorium Lavinium and Promontorium Olivium. Because west of the mountain gap two ruined rings form a bent wall suggesting to this writer a flying eagle, this wide exit might well be called Eagle Gate. Here, in 1953, the New York *Herald Tribune* science writer, using a small telescope, believed that he could see a natural span uniting the headlands. He noticed also a light spot west of the gap, and this bright area he interpreted as illuminated by the setting sun shining through under the bridge.

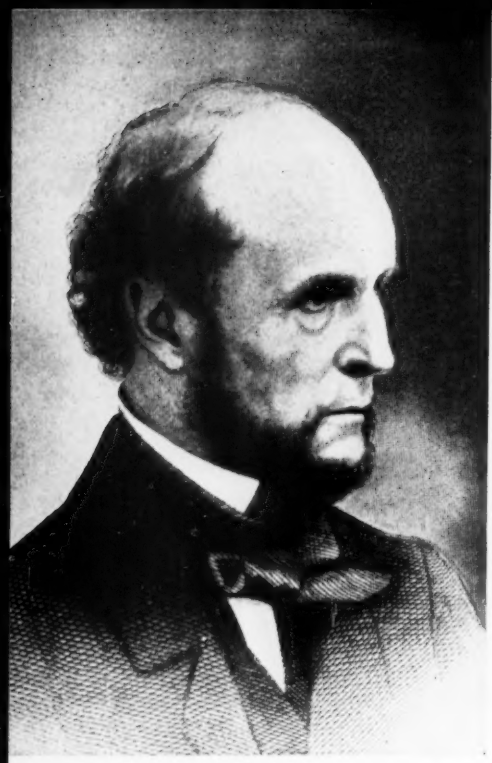
Just east of the great gate is an inconspicuous ring, whose western wall curves to suggest a connection between the headlands. Lying in the curve is a perched crater. Perhaps these details helped to conjure up a span. Also, when seeing is poor, the vibrating promontories seem to mingle across the chasm. But careful observation when Eagle Gate is near the terminator and night approaches from the west—when details should be plainest—suggests that the bridge was only another illusion.

This problem was discussed in great detail at a general meeting of the British Astronomical Association in November, 1954, when F. J. T. Maloney said, "The O'Neill bridge has no existence and . . . the topographical features described . . . on radio, and in the press have no counterpart in reality." K. W. Abineri told that he studied the bridge area carefully, but saw nothing to suggest the shadow of an arch. Dr. W. H. Steavenson also observed nothing resembling a bridge.

To sketch small lunar areas accurately

FACING PICTURE: The third of a series of four sections of the 4.6-day-old moon, the first of which appeared in February. Mare Crisium dominates this region; it is the lunar sea that is so prominent on the waxing crescent moon, seen in the western sky after sunset a few days following new moon. Between it and the moon's edge is the smaller, irregularly shaped Mare Marginis, seen unusually well here. In the lower right corner are craters named after two strong men of antiquity, Atlas and Hercules. Atlas is mostly in sunlight; to its right is Hercules, with its interior filled with shadow. This photograph is enlarged from a negative taken with the 36-inch Lick Observatory refractor, June 2, 1938.





Richard Adams Locke, author of the famous moon hoax of 1835.

is difficult, because they change with the movement of light and shadow, and because individual observers perceive them differently. This was emphasized by M. Gadsen at the same meeting: "All sketches, it seems, should be viewed with suspicion. When accredited observers disagree about large detail, ordinary observers must wonder what is going on."

An older example of probable misinterpretation is the case of Linné in Mare Serenitatis. As sketched in Goodacre's *The Moon*, Linné resembles the crescent and star of the Turkish flag, a mountain arc facing a small round hill. But small telescopes reveal only a white patch.

Lohrmann and Mädler found here a deep crater, but 30 years later Schmidt, the keen-eyed selenographer of Athens, reported that it had changed into a mere white spot. Hence some astronomers were persuaded that igneous agencies were still active on the moon. Goodacre later suggested that bright volcanic material coating the area reflects so efficiently that when the sun is high all detail is drowned.

Patrick Moore, on the other hand, is persuaded that Linné supplies the one certain case of surface change. Yet to assume that two selenographers made the same or similar mistakes is easier than to believe that a unique event occurred at this single site.

A somewhat similar formation is the low dim ring, Reiner Gamma, about 18 miles in diameter, just east of Reiner itself, in Oceanus Procellarum. It looks like an electric globe with a bright rod as a filament along the major axis, and a halo of light outside of the globe. But at times this nimbus resembles a white parallelogram. Here interpretative imagination has ample scope for play.

Because of the moon's almost unlimited variety, amateurs should not become excited if they find details not included in selenographic maps. That is to be expected in lunar charts as well as in terrestrial contour maps. They also should avoid hasty judgments.

In May, 1954, Frank Manning, of New Orleans, reported that, through his 20-inch Cassegrainian, he had observed a crack in Piccolomini, the large ring at the western end of the Altai range. This region was subsequently studied by J. Russell Smith, at Eagle Pass, Tex., and by David P. Barcroft, of Madera, Calif., a veteran lunar specialist whose name has been proposed for a crater northeast of Descartes and Dollond.

Smith watched Piccolomini through his 16-inch reflector, but always was unable to find the dark line, nor could he photograph it. Among others who have looked in vain for the crack are Walter H. Haas, editor of the *Strolling Astronomer*, and Jackson T. Carle, student of the lunar ring Plato. Commented Barcroft:

"I suspect the observer mistook Petavius, with its beautiful cleft, for Piccolomini. He was looking on the fourth lunar day, but Piccolomini cannot be seen until the fifth. On the floor of Piccolomini is no crack observable with a 10-inch reflector under fair-seeing conditions. Unrecorded detail is there, but small and not easily noticed. The same can be said for 500 other formations."

Among recent examples was the supposed tunnel through an apparent ridge on Mare Foecunditatis. As seen on the picture below, the twin craters Messier and W. H. Pickering resemble a two-headed comet, whose tail is two spreading rays toward the east. Studying observatory photographs, H. H. Nininger, authority on meteorites and owner of one of the largest collections of these visitors from space, proposed that a meteorite had made the twin by plowing through a long hill, forming the fanning tail (*Sky and Telescope*, June, 1952, page 192).

But if Messier and W. H. Pickering were tunnel portals, they should appear to us as narrow ovals rather than as circles or wide ellipses. Besides, the "ridge" is really a ray, as the Pennsylvania amateur, Elmer J. Reese, has pointed out; and this ray passes through Messier rather than between the twins. When night approaches them and shadows are long, even the ray disappears, and the crater pair can be seen lying alone on the relatively smooth gray plain.

In 1835, many Americans became the happy victims of the great moon hoax. Richard A. Locke wrote for the New York *Sun* a serial pretending to describe a remarkable new telescope and the strange things it had revealed to Sir John Herschel in South Africa. Among these were manlike creatures with bat wings. Much of this story, as popular in 1835 as belief in flying saucers is today, has been reprinted in the Griffith Observatory's publication, the *Griffith Observer*, for November, 1954.

Concerning the origin of the lunar craters, I do not believe in the questionable impact hypothesis, although professional astronomers, who rarely spare time for the moon, usually favor this supposition. But, as Patrick Moore pointed out in his March article, few modern practical observers have any use for the impact theory.

It was suggested as long ago as 1824 by

Near the center of this enlargement of a portion of Mare Foecunditatis are the twin craters Messier and W. H. Pickering, where H. H. Nininger suggested there might be a tunnel. Lick Observatory photograph.

the German astronomer Franz von Gruithuisen, whose name has been given to a 10-mile ring midway between Aristarchus and Sinus Iridum. (Gruithuisen also supposed that he had sighted huge fortifications on our satellite, but there were actually only low ridges.)

But the earth hardly shows any impact craters similar, both in form and size, to characteristic lunar rings; nor have cavities suggestive of early bombardments been pointed out among the Paleozoic strata of the Grand Canyon. Other arguments against the impact hypothesis can be based upon convex crater floors, central peaks, perched and hilltop craters, and horseshoe rings; polygonal rims and rims with spurs; crater twins, triplets, and chains; white spots, isolated mountains, laccoliths or bubble hills, and the Straight Wall; as well as rings within rings and the rugged collars of Copernicus and Aristillus—all suggestive of powerful igneous forces.

"In the night," as Shakespeare tells us, "how easy is a bush supposed a bear." Truly the moon is another gay deceiver, whose telescopic and photographic details often may mislead us. Once a maker of many lenses and mirrors believed he had discovered a lunar formation indicating oil. He even wrote to the federal government to try to register a claim on the site.

Two strange "glimpses of the moon" suggest the difficulties that trouble observers. One, in the west, is the apparently variable mountain just south of Proclus. Usually it is unobtrusive, so that richly shining Proclus dominates that region. But when the arc of night is approaching, this peak seems to rise to grand heights and to dwarf all its surroundings. Glimpsed for the first time, it encourages belief that a cataclysm has just occurred.

In the lunar east is another remarkable peak, which could be called "Star-tip Mountain." It is situated northeast of Schröter's Valley. It is, perhaps, the most striking of the mountains at dawn, when its summit catches the first sunlight. So brightly does it shine then that it reminds one of a star seen over the lunar limb. Adding to the pleasing effect is the group of faint sparks surrounding this glorious summit, smaller peaks that catch "the morning's first beam."

In a word, angles of illumination and observation, with changes in the observer's atmosphere, will explain many unusual details found in moonscapes. Observers should distinguish between fact and fancy, moonlight and moonshine. Remember that the earth's small companion is waterless and airless, and while still possible it is highly uncertain that igneous forces should yet be active on a few crater floors. Here, at least, skepticism is the better part of intelligence.

In the northeastern part of the moon, alongside Oceanus Procellarum, are these two craters, Aristarchus (left) and Herodotus, seen here as modeled by Nasmyth and Carpenter. Note the rugged country, with cracks and high mountains, to the north and east of the craters themselves.

Radio Observations of the Red Shift of Galaxies

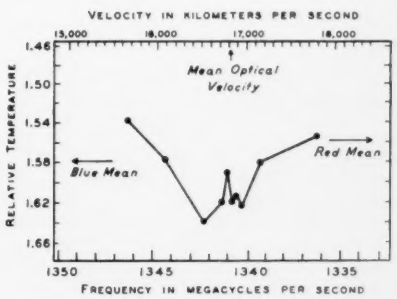
HITHERTO, the red shift of the spectrum lines of remote galaxies—usually interpreted as evidence that the universe is expanding—has been observed by optical methods only, by means of fast spectrographs attached to large telescopes. Now, for the first time, the red shift of a remote galaxy has been measured with radio techniques, by A. E. Lilley and F. F. McClain, of the Naval Research Laboratory, Washington, D. C.

The 21-cm. emission line of hydrogen is far too weak in distant galaxies to be observed directly with present-day radio telescopes. However, the intense radio source Cygnus A offers a special opportunity. This source is known to be a pair of colliding galaxies (see page 298 of the July, 1954, issue) that has a strong continuous spectrum at microwave frequencies.

If there is neutral hydrogen gas associated with these galaxies, on the near side of the collision region, then the intense radio radiation would have to pass through the neutral hydrogen before escaping into intergalactic space. Such neutral hydrogen would then produce an absorption line in the radio spectrum of Cygnus A. But because of the high speed of recession of these galaxies—observed to be 16,830 kilometers per second by W. Baade and R. Minkowski at Mount Wilson and Palomar Observatories—this absorption line should not be at the normal position in the spectrum. A red shift of 17,000 kilometers per second corresponds to a change in frequency of about 81 megacycles per second from the undisplaced 21-cm.-line frequency of 1420.4 megacycles.

Such an absorption line was sought for and found by Drs. Lilley and McClain with the 50-foot NRL radio telescope. Their observations consisted in comparing, at various wave lengths, the relative brightnesses of Cygnus A and Cassiopeia A, using the latter source as a standard. The nearness of these two most intense radio sources to each other in the sky permitted alternate observations at periods of about one hour, a procedure designed to eliminate effects of ground reflections, altitude of the antenna, and atmospheric extinction. In general, one source was observed for about 45 minutes; the antenna was turned to the second source (a change that required about 10 to 15 minutes) and the same set of observations was made; then the first source was observed again, and so on. In all, approximately 1,000 determinations of temperature were made.

The Cygnus source showed an unmistakable weakening in radiation temperature in a band with an approximate half width of 850 kilometers per second, centered at a frequency corresponding to a recession of about 16,700 kilometers per second. This agreement with the spectrographic data of Baade and Minkowski is evidence that the red-shift displacement of spectrum lines in very distant galaxies is proportional to wave length, over a range of 500,000 to 1 in the electromagnetic spectrum. This result is of considerable cosmological importance.



Radio telescope observations at the Naval Research Laboratory, of the 21-cm. absorption line of hydrogen in Cygnus A, show the line displaced by the red shift from its normal frequency of 1420.4 megacycles per second. The ordinates are the observed temperature of Cygnus A divided by that of the comparison object, Cassiopeia A. Blue and red means are shown for temperature ratios at greater and lesser frequencies outside the hydrogen line.

Rasalgethi is the star in Hercules' cheek, according to this drawing in Bayer's "Uranometria" of 1603. The Kneeler's feet are toward the north in the sky. Courtesy, Houghton Library, Harvard University.

Alpha Herculis

OTTO STRUVE

Leuschner Observatory

University of California

RISING along the northeastern horizon these April evenings is one of the largest of the ancient constellations, Hercules, the Kneeler. Among its brightest stars is Rasalgethi, which has been known as a naked-eye variable for over a century. Its brightness changes unpredictably within the magnitude limits 3.0 and 4.0, in irregular cycles of several months duration.

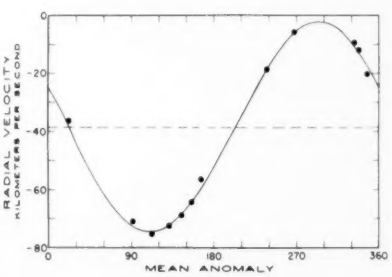
To observers with small telescopes, Alpha Herculis is also well known as a beautiful visual double star with a 5.6-magnitude companion about five seconds of arc distant from the bright red primary, which is the variable star. The latter is a supergiant of spectral class *M5*, with a surface temperature of 2,700° absolute. The companion is observed to be a yellow giant of class *G0*, with a temperature of 5,200°, slightly less than the sun's.

But although this companion appears as a single star in even the largest telescopes, the spectroscope reveals it to be a close binary system. The lines in the spectrum of the visible *G0* component alternately shift back and forth and indicate that there are really two stars revolving about each other. The velocity curve of the *G0* star was recently determined by A. J. Deutsch at the Mount Wilson and Palomar Observatories, and is reproduced here. Its radial velocity (line-of-sight motion), as determined from the Doppler displacement of its spectrum lines, varies by 72 kilometers per second in a period of 51.6 days.

The spectrum lines measured by Deutsch for this purpose all belong to the *G0* star, but they appear hazy or veiled, as though they were overlaid by the continuous spectrum of the fainter component of the spectroscopic binary. Deutsch also noticed that the broad absorption lines of ionized calcium appear blended, as if they were produced by two stars: the brighter *G0* component, and a fainter star of earlier spectral type, perhaps *A3*. If this third member of the system of Alpha Herculis is a main-sequence star, its visual apparent magnitude is 7.7, and its temperature about 9,100°.

Presumably, the red supergiant and the spectroscopic pair are in orbital motion around each other, but the period must be very long. According to O. J. Eggen, the position angle of this wide pair seems to be changing by 9/100 of a degree per year, or 360 degrees in about 4,000 years; this result will be referred to later. The angular separation between the visual components is also presumably changing, an effect of their revolution; at present they appear 4.7 seconds of arc apart on the sky.

It is therefore easy to separate, on the slit of the spectrograph, the light of the *M* supergiant from the combined light of the *G0* and *A3* components. Typical spectrograms of Alpha Herculis, taken by Deutsch, are seen here. Spectrum I shows the *G0-A3* pair on August 23, 1954, when the *G0* star was approaching us at 64 kilometers per second. The second spectrum, also of this pair, was taken on July 14, 1954, when the velocity of approach of the yellow star was 19 kilometers per second. On spectrum III, obtained on the same night for the *M5* star, its motion was 36 kilometers per second toward us. In the three spectra, these relative velocities can be easily detected by examining the Doppler shifts of some of the lines of intermediate intensity. For example, the iron lines at 4250.1 and 4250.8 angstroms are strongly shifted to the left

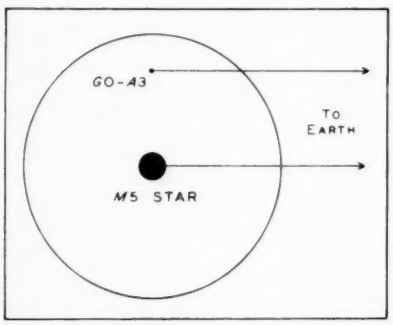


The variation of the line-of-sight motion of Alpha Herculis B is plotted in terms of its mean anomaly (time since periastron passage counted as 360 degrees per orbital period). The to-and-fro movement of the G-type star is caused by its revolution around the center of gravity of the binary system it forms with the A3 star. Diagram from Mount Wilson and Palomar Observatories.

(violetward) in I, with respect to the comparison lines. In II they almost coincide with the comparison lines, and in III they occupy an intermediate position.

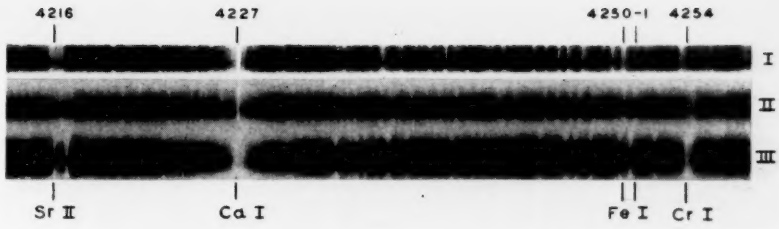
But if we examine the strong line of neutral calcium at 4227 angstroms, we find that it has very nearly the same position on all three strips. This line shows none of the spectroscopic pair's orbital motion, which is indicated so clearly for the iron lines in I and II. The measured radial velocities of the 4227 line on I, II, and III are 40, 40, and 46 kilometers per second of approach, respectively. These three observations by Deutsch have led to one of the most exciting advances in stellar spectroscopy in recent years. To understand this, we shall look into the causes of these different line behaviors.

The strong calcium line is relatively stationary in both the *M*5 and the *G*0-*A*3 spectra. It does not share the orbital motion of the close pair, nor is its velocity identical with that of either the *M*5 star or the center of mass of the spectroscopic pair. Several other such stationary lines are found in the same spectra, among them a number of strong lines of neutral iron, the H and K lines of ionized calcium, and the neutral sodium lines in the yellow.



In this representation of Deutsch's model of Alpha Herculis, the diameter of the red supergiant star is greatly exaggerated. Deutsch has assumed that the radius of the tenuous shell (outer circle) is 1,000 astronomical units and that the companion pair is at the same distance from us as the M5 star. On this basis, the pair is about 700 astronomical units from the M supergiant.

It had already been known, largely from the work of W. S. Adams and his associates at Mount Wilson, that the strongest absorption lines of the red supergiants are often peculiar; their radial velocities usually show an approach, relative to the velocities obtained from the weaker absorption lines. On spectrograms of very high dispersion, the strong lines are frequently double. The red components appear to originate in the star's reversing layer, for they have the same Doppler shifts as do the weaker lines. But the violet components have Doppler shifts suggesting that they arise in outer, expanding layers of gas which surround the



These coude spectra were taken by A. J. Deutsch with the 200-inch telescope (I) and the 100-inch telescope (II and III) to record variations in the line positions and spectral characteristics of Alpha Herculis. Spectra I and II are of the spectroscopic pair; spectrum III is of the red supergiant. Courtesy, Mount Wilson and Palomar Observatories.

reversing layer. Most investigators surmised that these strata extended above the surface of the supergiant to elevations of about the radius of the star itself.

We already knew that the red supergiant stars are very large, and Alpha Herculis is one of the hugest of them. Its angular diameter had been measured with the Mount Wilson interferometer by F. G. Pease, who found 0.030 second of arc. Deutsch suggests that the diameter is 0.036 second, and that the star's distance from us is about 150 parsecs. This would make the radius of the *M*5 star about 580 times that of the sun, or some 250 million miles. We were thus prepared to expect a shell almost three astronomical units deep, surrounding the red supergiant star itself.

But we were not prepared for Deutsch's inescapable conclusion: The same stationary absorption lines produced by the shell seen in front of the *M*5 supergiant are also found in the spectrum of the *G*0-*A*3 combination. The shell therefore extends at least as far as the distance between the components of the visual double star—nearly five seconds of arc! At a distance from us of 150 parsecs, this separation is 700 astronomical units, and it may be considerably more if one component of the visual pair lies beyond the other.

Even this enormous extent for the shell may be an underestimate, for there is no reason to suppose that the shell surrounding the *M*5 component ends abruptly at the distance of the spectroscopic pair. It may extend several times that far from the center of the red supergiant, and it may, in fact, gradually merge into the diffuse gaseous medium of interstellar space.

Deutsch's final measurements lead to the following radial velocities, all of approach relative to the sun, and expressed in kilometers per second:

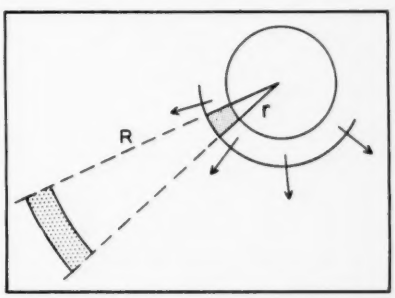
Reversing layer of *M*5 star	35.2
Center of gravity of *G*0-*A*3 pair	38.4
Shell in front of *M*5 star	45.0
Shell in front of *G*0-*A*3 pair	39.5

These values are believed to be precise within 0.1 or 0.2 kilometers per second.

The reversing layer value is that for the *M*5 star itself; the difference between this and the center of mass of the *G*0-*A*3 pair, 3.2 kilometers per second, represents the orbital motion of the wide visual double star. We may assume, from other considerations, that the masses of the *M*5, *G*0, and *A*3 stars are 15, 4, and 2 suns, respectively, making a total of 21 solar masses. Assuming that the linear separation in the visual pair is 700 astronomical units, we can calculate from Kepler's third law that the period of orbital motion is roughly 4,000 years, which is in agreement with Eggen's value for the position angle change of 9/100 degree per year.

As the table shows, the atoms of the shell in front of the *M*5 star are approaching at 45.0 kilometers per second, while the star as a whole is approaching at 35.2. The shell is therefore expanding from the supergiant at an average rate of 9.8 kilometers per second. If this rate is uniform, the density of the shell decreases as the square of the distance from the *M*5 star. Therefore, there should be considerably less gas of the shell seen before the spectroscopic pair than in front of the red supergiant. The stationary lines of the *G*0-*A*3 spectrum are, in fact, much less intense than those of the *M*5 star, as Deutsch's spectrograms show.

Moreover, the line-of-sight component of the velocity of expansion observed in front of the close pair should be smaller than that in front of the supergiant primary. The actual difference is only 1.1 kilometers per second (39.5 − 38.4). But presumably this pair is moving away from



The effect of expansion on the density of a uniformly expanding shell of gas. The density is proportional to the square of the fraction r/R, as long as the outward velocity remains unchanged.

This is an enlargement of part of a Harvard Observatory photograph taken May 5-6, 1951, exposure 83 minutes. At the left, the bright star is Alpha Ophiuchi, and Alpha Herculis is centered about 1½ inches from the top; they are about five degrees apart. North is upward.

us (relative to the red supergiant) at 3.2 kilometers per second, through the shell centered on the *M5* star, and which as a whole shares its motion of 35.2 kilometers per second. Therefore, the true mean velocity of shell expansion along the line of sight to the *G0-A3* pair is 39.5 − 35.2 = 4.3 kilometers per second.

The temperature of a gas is important in controlling the amount of its ionization, that is, the disruption of its component atoms into ions with positive and negative electrical charges. From the relative intensities of the lines of neutral and ionized calcium, Deutsch could conclude that the state of ionization of the shell of Alpha Herculis resembles that in a normal stellar atmosphere with a temperature of about 5,000°. But the shell is much less dense than a normal reversing layer. If this were the only difference, a much lower temperature than 5,000° could provide the observed ionization.

But there is another important difference. The ultraviolet stellar radiation that produces the ionization is greatly reduced in amount. In the reversing layer, a calcium atom receives radiation from a solid angle of at least one hemisphere, but at a representative point in the shell the apparent disk of the exciting star is small. At 700 astronomical units, the disk of even as big a star as Alpha Herculis would cover only 1/150,000 of a hemisphere of the sky. The *amount* of exciting radiation that reaches this distant atom would thus be roughly 150,000 times less than if the atom were located at the surface of the *M5* star. We describe this effect by saying that the radiation is *diluted* by a factor of 150,000.

The degree of ionization is reduced in the same ratio, because it is proportional to the amount of radiation received. But at the same time, at 700 astronomical units, the density of the shell is only about 1/100,000 its value near the star. Therefore, since ionization is greater the lower the density, these two effects tend to cancel out. Consequently, in a uniformly expanding shell the degree of ionization remains roughly the same, regardless of distance from the central star.

Deutsch believes that in Alpha Herculis the ionization is produced by the much hotter but also much smaller *A3* component of the triple system. Even so, its radiation is insufficient to disrupt any appreciable proportion of hydrogen atoms. The heavier atoms, like calcium and iron, require less energy to be disrupted, and they are for the greater part once ionized. Each such atom has lost one electron from its outer shell. The calcium and iron atoms supply the required number of free electrons—about one million per cubic centimeter. There are about 30,000 calcium atoms and 10^{10} hydrogen atoms in the same volume.

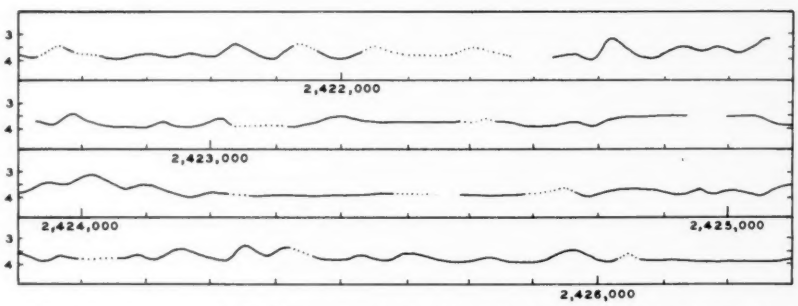
The entire shell contains some 10^{49} cubic centimeters, if we assume with Deutsch that the shell's radius is 1,000 astronomical units. If each cubic centimeter contained 10^{10} atoms, the total would be 10^{59} atoms. But this would comprise 10^{35} grams, an enormous amount of matter, more than the combined mass of all three stars! However, Deutsch was able to infer from the intensities of the stationary absorption lines that the total mass of the shell is approximately 10^{28} grams.

The only way to reconcile the high density of the ionized material in the shell with its relatively small mass is to assume that the volume is not completely filled with gas, but that the latter is concentrated mostly in dense clouds which occupy only $10^{28}/10^{35} = 10^{-7}$ of the entire volume. Deutsch calls this the "packing fraction" of the shell, and envisages the individual clouds as formations resembling solar prominences which may have been expelled from the atmosphere of the *M5* star by intense magnetic fields at its surface.

Whatever the original cause of the expansion may be, the velocity of escape from the entire mass of the system is only six kilometers per second at the rim of the shell. Since the observed rate of expansion is 9.8 kilometers per second, the material is almost certainly escaping into interstellar space. The rate of this escape is 10^{25} grams per year. The *M5* star would exhaust nearly all its present mass in one billion years were it not for the fact that the supergiant stage of such a star does not last that long. On the other hand, Deutsch's estimate of the loss of mass per year is a lower limit; it may well be 10 or more times greater. If so, the supergiant could actually be transformed into a star of moderate mass within, say, one hundred million years.

There is little doubt that similar enormous expanding shells surround all red supergiants, such as Betelgeuse, Mira Ceti, VV Cephei, and many others. But the

(Continued on page 263)



The variations in the brightness of Alpha Herculis during a 13-year interval, from October, 1917, to November, 1930. The numbers represent Julian days, and the scale at the left is visual apparent magnitude. This is part of a more extended light curve compiled by H. van Schewick. From the "Astronomische Nachrichten."

NEWS NOTES

By Dorrit Hoffleit

ORIGIN OF PLUTO

There are strong reasons for believing that the outermost known planet, Pluto, was formerly a satellite of Neptune which escaped during the formation period of that planet, according to G. P. Kuiper, of Yerkes and McDonald Observatories. The small size and slow rotation of Pluto, as well as the marked eccentricity of its orbit, which intersects that of Neptune, suggest an origin different from other planets.

On Dr. Kuiper's view of the origin of the solar system, Neptune (like the other planets) came into being from a larger, more diffuse protoplanet, which lost most of its mass by evaporation. During this decrease in mass, the satellites of Neptune would recede from the planet, and one of them could have escaped entirely to become an independent planet, Pluto. A process of the same kind, occurring in the case of Jupiter, may explain the Trojan asteroids as escaped Jovian moons. Dr. Kuiper is publishing a two-part review article on the origin of the solar system, in which he describes these processes, in the *Journal* of the Royal Astronomical Society of Canada, beginning with its March-April issue.

If Pluto were thus originally a not-too-distant satellite of Neptune, making one rotation during each orbital revolution just as the earth's moon does, it should retain substantially the same rate of rotation after escaping. Recently, M. F. Walker and R. Hardie have determined that the rotation period of Pluto is 6.39 days, the longest for any outer planet (*Sky and Telescope*, January, 1956, page 121), in agreement with the expectations of Dr. Kuiper's theory.

As for the eccentricity, it is unlikely that Pluto's orbit could have changed from a circle to its present shape through perturbations by a passing star, especially since the orbit of Neptune is nearly a perfect circle now.

About 20 years ago, the English astronomer R. A. Lyttleton suggested that Pluto was once a satellite of Neptune, and that it was ejected through a close encounter with the other large satellite, Triton (*Sky and Telescope*, May, 1940). Dr. Kuiper believes it unlikely that such an encounter could ever have occurred.

60-FOOT RADIO TELESCOPE

On April 28th, America's largest reflector-type radio telescope will be dedicated at Harvard Observatory's Agassiz station, 30 miles west of Boston. Its construction has been made possible by financial aid from the National Science Foundation.

The 60-foot-diameter paraboloidal reflector has a focal length of 21 feet. Made of expanded aluminum mesh, each opening 3/8 inch wide, and supported by tubing, the antenna weighs 8,000 pounds. It is carried by a motor-driven equatorial mounting and can be pointed toward any part of the sky. The structure is designed to operate with precision in winds up to 25 miles per hour, and with less precision up to 45 or 50 miles per hour. With the reflector in its stowed position, the telescope should withstand winds of hurricane force. It has been built by D. S. Kennedy and Co., Cohasset, Mass.

The reflector will be used in connection with an electronic receiver especially designed for observations of the 21-cm. hydrogen line. Simultaneous recordings will be possible on 20 channels, covering wave lengths near the hydrogen line.

A model of the 60-foot radio telescope nearing completion at Harvard's observing station in Massachusetts. The main supporting pier is tilted to permit the big dish to point directly at the horizon completely around the sky.

SUMMER INSTITUTE FOR SCIENCE TEACHERS

In an effort to improve science teaching, particularly in the field of astronomy, the National Science Foundation is sponsoring a summer institute at Wisconsin State College, Eau Claire, Wisc., from June 18th to July 13th. About 50 science educators, primarily faculty members of colleges that train science teachers, will be instructed on current concepts and techniques of astronomy, with special emphasis on ideas for science teaching. The institute is also open to some high school supervisors and teachers, and operators of planetariums.

Mornings will be devoted to classroom lectures, with informal discussions in the afternoon. Frequent observing sessions will also be held, emphasizing the many uses of small instruments. Participants are invited to bring portable observing equipment.

The instruction staff will include astronomers Frank K. Edmondson, University of Indiana; Freeman D. Miller, University of Michigan; William H. Pinson, Massachusetts Institute of Technology; and Carl K. Seyfert, Vanderbilt University. Dr. W. A. Calder, Bradley Observatory, Agnes Scott College, is director of the institute.

Subsistence grants will be awarded to those participating; there will be 50 stipends of $200 each, plus an allowance for dependents when applicable. Attendance at the institute is not, however, limited to those who receive these grants. Dr. Charles Koelsche, assistant director of the institute, Wisconsin State College, Eau Claire, Wisc., can supply application blanks and further information.

IN THE CURRENT JOURNALS

EARLY HISTORY OF RADIO AS TRONOMY, by George C. Southworth. *Scientific Monthly*, February, 1956. "Are discoveries invariably predicted by prior theory or experiment or are they more often purely accidental or at best based on a good hunch? Examples of at least two of these three possibilities appear in the relatively new subject, radio astronomy."

THE CLOUDS OF MAGELLAN—A GATEWAY TO THE SIDEREAL UNIVERSE, by Harlow Shapley, *American Scientist*, January, 1956. "Whatever the evolutionary trend, the irregular dust-and-gas rich Magellanic Clouds appear to possess many characteristics of youth."

ASTRONOMICAL SCRAPBOOK

Mars at Its Nearest

THE LIFE of every regular observer of Mars is markedly affected by a cycle of two years and two months, the average interval between oppositions of this planet, for it is only during a few short months, centered on the time of opposition, that useful telescopic observations of it can be made. The changing distance of Mars from the earth causes a variation in apparent size unmatched by any other of the principal planets. When Mars is on the far side of the sun, its minute featureless disk can appear smaller than Uranus; at a favorable opposition it shows a face about 1/70 as broad as the moon's, as will be the case this September.

If when Mars comes to opposition it is also passing through perihelion, its distance from the earth can be as small as 34.6 million miles; when opposition occurs at the time of aphelion, Mars does not approach closer than 62.9 million miles. Articles on Mars and every textbook account tell how the more favorable oppositions take place at 15- or 17-year intervals, as in 1877, 1892, 1909, 1924, 1939, and 1956. But there is also a much more nearly exact repetition of close approaches of Mars in a cycle of 79 years.

Thus the circumstances of the coming September 11, 1956, opposition will closely match those of the historic return of September 6, 1877, at which Asaph Hall detected the two satellites of Mars, and Schiaparelli began his observations of the canals. Going back farther by 79-year stages takes us to 1798, when Schröter made a long and unprecedented series of drawings of the red planet; and to 1719, when Mars on opposition day, August 29th, was only 2° 30′ from the perihelion of its orbit.

In 1719, Mars was assiduously studied at the Paris Observatory by G. F. Maraldi, with a nonachromatic refractor 34 feet long. His drawings show the south polar cap and considerable dark detail.

If we trace back in the same way the earlier counterparts of the most favorable opposition of this century, that of August 23, 1924, a tragic sequence of lost opportunities is uncovered. In 1845, when Mars came within 34.7 million miles, only a few desultory drawings were made, and in 1766 no instrument more powerful than a 3½-inch refractor was turned on the planet.

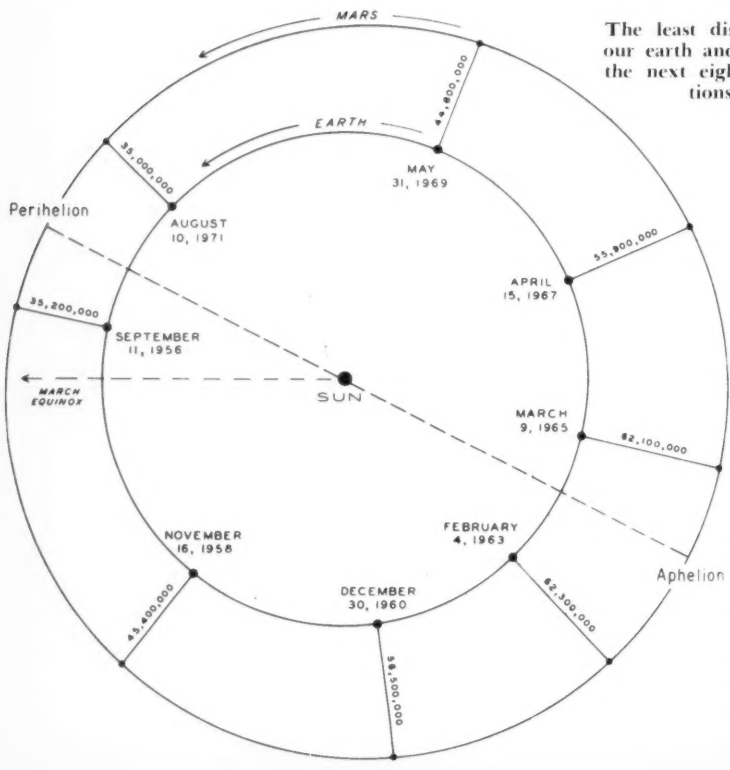
After this year, the next four particularly favorable oppositions will come in the years 1971, 1973, 1986, and 1988. Some details of these are given in the following table, adapted from a more extended list computed by the Italian amateur Enzo Mora, and published by him in the *Astronomische Nachrichten, 183*, 165, 1909. The dates he gives seem reliable within a day or two, from the few checks I have made. It will be noticed that the time of closest approach may differ by more than a week from the time of opposition—a consequence of the paths of the earth and Mars not in general being parallel at opposition. The least distances, diameters, and magnitudes refer to the date of nearest approach.

If, however, we consider close approaches of Mars to the earth in the remoter future, a new picture unfolds. Imagine that, from some vantage point far above the earth's north pole, we can see the planetary orbits as visible loops. From century to century, these orbits are gradually changing in shape and orientation, because of the gravitational attractions of the planets upon one another. The path of Mars is an ellipse that slowly is becoming more elongated, while the earth's orbit is approaching circularity. The longest diameters of both ellipses are gradually turning counterclockwise, and meanwhile the angle between the two orbit planes is decreasing.

All these changes combine to alter slowly the least possible distance of Mars from the earth at most favorable oppositions. Observers in the distant future—even without benefit of space travel—will be able to view Mars at closer range than is now possible. Six thousand years ago, Mars at best could approach to 35.2 million miles, when it was at perihelion on the day of opposition, with an angular diameter of 24.7 seconds. By A.D. 3000, Mars at perihelion opposition will be able to come to 33.4 million miles from us, and its diameter will reach 26.1 seconds.

Another effect of the changing orbits of the earth and Mars is that the calendar date of the most favorable possible opposition is coming later and later in the year. Around 4000 B.C. this was June 12th, and by A.D. 3000 it will be September 18th. Our more astronomically-minded descendants may then be studying Mars with appliances as undreamed of as the 200-inch Palomar telescope would have been to Copernicus.

J. A.



The least distances of our earth and Mars at the next eight oppositions.

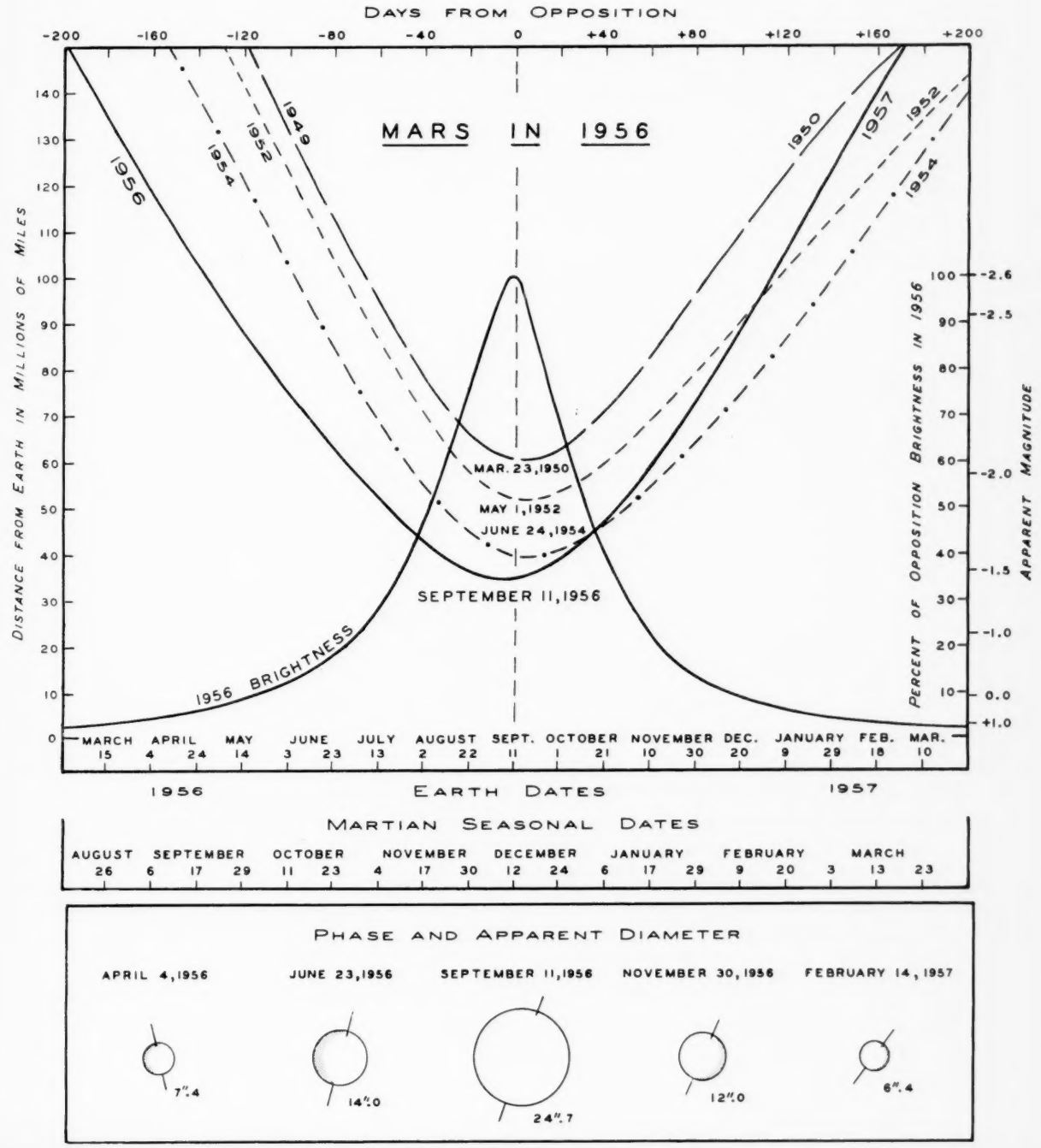
Year	*Opposition*	*Nearest Earth*	*Millions of Miles*	*Diameter ″*	*Magnitude*
1954	June 25	July 2	39.8	21.9	−2.2
1956	Sept. 11	Sept. 7	35.2	24.8	−2.6
1958	Nov. 16	Nov. 8	45.4	19.2	−1.9
1960	Dec. 30	Dec. 25	56.5	15.4	−1.3
1963	Feb. 4	Feb. 3	62.3	14.0	−1.0
1965	March 9	March 12	62.1	14.0	−1.0
1967	April 15	April 21	55.9	15.6	−1.3
1969	May 31	June 9	44.6	19.5	−1.9
1971	Aug. 10	Aug. 12	35.0	24.9	−2.6
1973	Oct. 25	Oct. 17	40.5	21.4	−2.2
1975	Dec. 15	Dec. 9	52.5	16.5	−1.5
1978	Jan. 22	Jan. 19	60.7	14.3	−1.0
1980	Feb. 25	Feb. 26	62.6	13.8	−0.9
1982	March 31	April 5	59.1	14.7	−1.1
1984	May 11	May 19	49.5	17.6	−1.6
1986	July 10	July 16	37.6	23.2	−2.4
1988	Sept. 28	Sept. 22	36.6	23.8	−2.5
1990	Nov. 27	Nov. 20	48.1	18.1	−1.7
1993	Jan. 8	Jan. 3	58.2	14.9	−1.2
1995	Feb. 12	Feb. 11	62.9	13.8	−0.9
1997	March 17	March 20	61.3	14.2	−1.0
1999	April 24	May 1	53.8	16.2	−1.4

A Graphic Time Table of Mars

A BIRD'S-EYE VIEW of the close approach of Mars in 1956 is given by this graphical representation. The heavy curve in the upper part of the diagram, labeled 1956 and 1957, shows how the distance of Mars from the earth decreases steadily to a minimum of 35,200,000 miles on September 7th, four days before opposition. For comparison, corresponding curves of the Martian distances during 1950, 1952, and 1954 are plotted; these are superimposed so the corresponding opposition dates match.

In the lower part of the same diagram, the brightness of Mars during its 1956 appearance is plotted; the light curve is sharply peaked, as it is in terms of actual intensity instead of the conventional magnitude scale; both scales are shown at the right.

The Martian seasonal dates are based on the position of the sun (as seen from Mars) with respect to the equinox of Mars that corresponds to the March equinox on the earth. When the planet is nearest us this year, the Martian northern hemisphere is having winter, and the south pole is turned toward us. The orientation of the planet's axis is shown by the series of five drawings, in which south is at the top. Apparent size and phase are also indicated as they will be seen in an inverting telescope.



Iris Photometry of Stellar Photographs

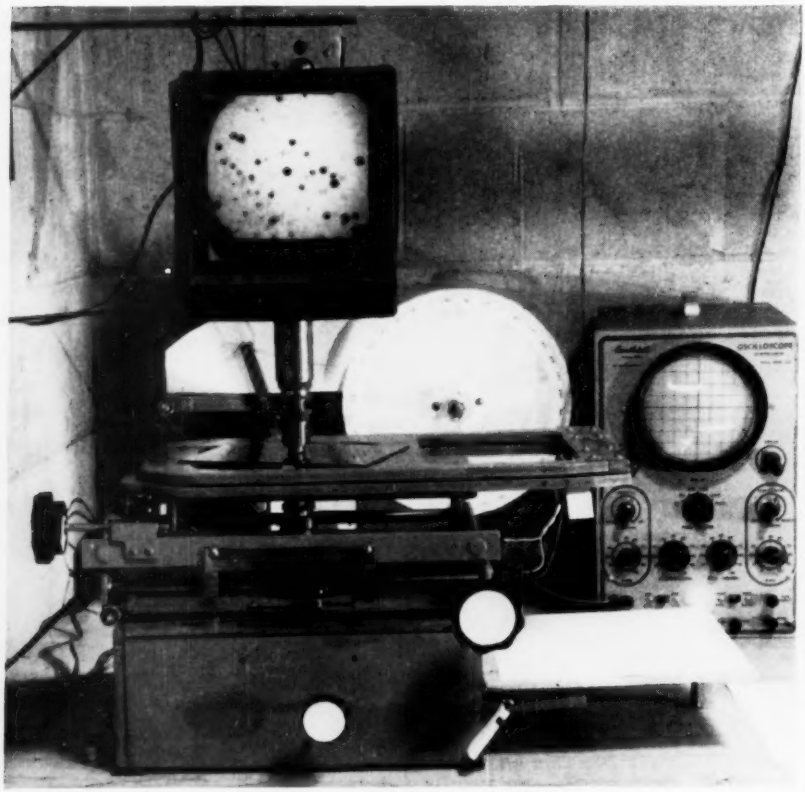
JAMES CUFFEY, *Goethe Link Observatory, University of Indiana*

PHOTOGRAPHS of star fields show stars of different brightnesses as circular disks with differing diameters. This is a result of the diffusion of light in the emulsion outward from the star's image. Therefore, photographic images of bright stars are many times as large as the visual images produced by the same telescope, a fact that might seem at first to be a serious drawback, since it limits the resolving power of the photographs.

In practice, however, the various sizes of images turn out to be valuable because a simple measure of the diameter of an image on the photographic plate gives us a quantitative idea of the star's brightness.

To measure photographic star images like those shown highly magnified in the accompanying picture, we might attempt by eye to estimate their diameters, relative to a linear scale in a microscope eyepiece or to a series of disks of graduated sizes held near the star images on the plate. These methods have been used in the past, but they introduce subjective errors because the eye is unable to add up properly the numbers of blackened emulsion grains in a given image.

Effective image diameters can be measured more efficiently by photoelectric means, which also allow for varying blacknesses of the images and for their somewhat fuzzy boundaries. The numerical reading of a photoelectric photometer used in this way represents the effective diameter of the image and, therefore, the star's brightness with an unusually high accuracy—second only to that achieved by letting the starlight fall directly on a photoelectric cell attached to the telescope itself.



The new iris photometer constructed by the author, as seen by the operator. In the upper left, the viewing screen shows a star field near a globular cluster. The oscilloscope is at the right, where it indicates an out-of-balance pattern. On the right side of the base, a white platform holds star identification charts. The control knobs and other parts are described in the article. A rectangular photographic plate is at left center, placed for measurement of one of its images.

Early photometers operated by projecting a small circular spot of fixed size upon the star image, and measuring with a thermocouple or photocell the amount of light the star image blocked out of the beam. These instruments, such as the Stetson, the Schilt, and the Ross photometers, gave greater accuracy than the eye, but their measuring range was limited by the fixed size of the spot, as well as by the fact that the edges of the larger images spilled over the edges of the spot of light. In addition, the illumination in the spot, which was furnished by a lamp filament, tended to vary, and the measures had to be corrected for the drift in brightness of the spot.

Modern photometers give increased accuracy and vastly greater range of measurement because they adopt a principle suggested by H. Siedentopf in 1935 (*Astronomische Nachrichten*, 254, 33). He proposed that an iris of variable diameter be used to provide a spot of varying size into which the star image may be placed. The iris is then adjusted so the same amount of light passes around each star image.

Two distinct advantages result from this method. The larger images no longer spill over the edges of the iris image, since the latter is now always larger than the star image. And the photocell now measures a fixed quantity of light, thereby giving more uniform performance. A further improvement, used in the "Astrophotometer" by L. C. Eichner and others (*Astronomical Journal*, 53, 25, 1947), is to let the photocell compare the light coming through the iris image with the light directly from the lamp, removing the effects of any changes in the brightness of the source.

As might be expected, a striking improvement in accuracy has resulted with photometers that use Siedentopf's iris

principle and Eichner's beam-comparison method. The present construction of such photometers as that by H. Haffner (*Veröffentlichungen der Universitäts-Sternwarte Göttingen*, No. 106, 1953) has been made easier by the availability of photomultiplier tubes, cathode-ray oscilloscopes, and other electronic equipment.

The need for an iris photometer at the Goethe Link Observatory led me to design and build a relatively compact instrument that applies these principles. It has been in use for some two years and has given surprisingly good performance, although materials and parts cost considerably less than $300. Its construction required about two months.

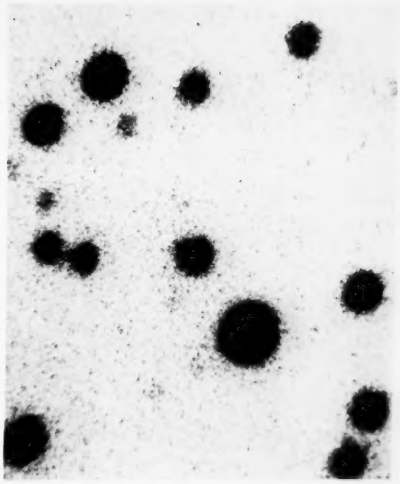
The major components of the instrument are the photometer proper, the photomultiplier (RCA 931-A or 1P21) with its hearing-aid battery voltage supply, and a conventional a.c. oscilloscope. The photometer proper consists of the optical system, the iris and its reading mechanism, the carriage for moving the plate in x and y co-ordinates, the viewing screen, and the framework which holds these parts rigidly relative to one another. The 931-A photomultiplier tube works well enough, but the more expensive 1P21 offers a slight advantage for more critical work. The a.c. oscilloscope was put together from a kit purchased several years ago for under $40.

In the diagram, the relationship of the optical parts is shown. Light leaves a 6-volt, 32-candle-power auto headlamp bulb, powered by a storage battery, along two paths. One, the measuring beam, passes through the collimating lens, the iris, the lower objective lens, and the star plate, where the iris image is formed on the emulsion. Then the light goes through the upper objective to a mirror system that permits visual inspection of the image on the viewing screen. Part of the light goes on through the half-silvered mirror, field lens, and chopper, then falling upon the upper half of the photomultiplier cathode (the light-sensitive surface).

The other, or monitor beam, passes through two lenses and the chopper, and is received on the lower half of the cathode. The square wave produced by the alternate chopping of the two beams is displayed on the oscilloscope screen, and a leveling out of the square-wave pattern into a straight line indicates equality of the two beams. Suitable apertures and neutral filters regulate the amount of light in each beam to prevent overloading the photomultiplier, and to permit adjustment of the illumination of the iris spot on the plate.

The chopper disk is carefully balanced to prevent vibration. The chopping speed should be as slow as possible, consistent with the interval represented by the persistence of vision, which might limit one's speed of setting on the cathode-ray tube display. The high-frequency noise content in the square-wave pattern due to the photomultiplier (and perhaps to the relatively small filament of the auto headlamp bulb) may then be smoothed out by a suitable time-constant capacitor, without at the same time destroying the sharpness of the square-wave pattern.

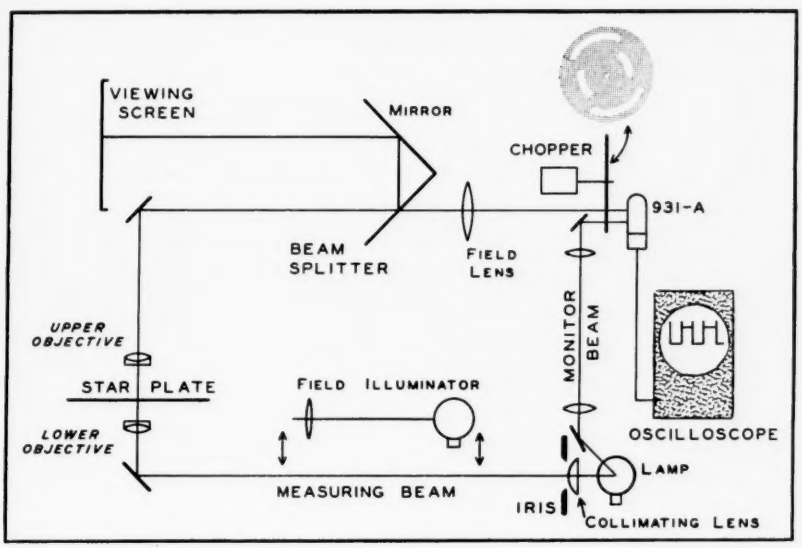
It was found desirable to allow the phototube to experience a short dark period between examinations of the measuring and monitor beams. This was accomplished by cutting the slots in the chopper a trifle shorter than necessary, so that for a short interval no light from either beam falls on the photomultiplier. The return to dark current produces a large negative peak on each side of the square-wave plateau, which is always present, even when the square wave has been leveled off in balancing the beams. The peaks are used by the oscilloscope internal synchronizing circuit to keep the display from wandering, in case the chopper motor's speed is not constant. An inexpensive phonograph motor can then be used to turn the chopper, since the oscilloscope hold circuit has a cueing signal, even when it sees a balanced square wave, and automatically synchronizes itself with the chopper.



These star images are magnified about 37 times from a 103a-D plate taken with the 36-inch reflector. While large images have well-defined boundaries, fainter ones fade gradually into the plate-grain pattern without becoming much smaller. All illustrations with this article are from the Goethe Link Observatory.

The framework of the photometer is an electrically welded yoke of 4-by-1½-by-¼-inch channel iron. The inside dimensions of this yoke are 20½-by-17-by-13½ inches. Added rigidity is given by a welded box beam at the rear, made of two pieces of the channel iron.

Attached to the vertical part of the framework is the measuring element, which consists of a microscope substage iris with 11 leaves. The iris opening can be varied from 1/16 inch to one inch. A lever arm eight inches long was rigidly fastened to the short lever already present on the iris itself. A 30-pound nylon monofilament fishing line links the lever arm to a small ¾-inch-diameter drum. The drum carries the iris reading scale, a 0-360-degree protractor 10 inches in diameter. As the iris opening is varied by motion of the lever, the rotation of the drum and protractor scale gives a highly magnified indication of the iris size. The mechanical magnification is approximately 50. It was found essential to make the protractor mount very light and rigid to avoid vibration. The paper protractor scale was glued to a light balsa wood frame, and the whole was sprayed



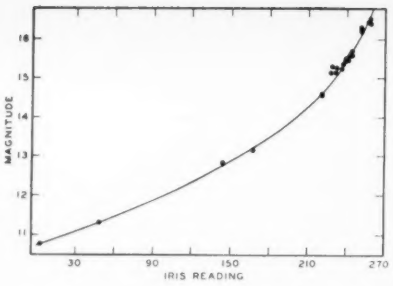
In this diagram of the optical system of the iris photometer, arrows indicate how the field illuminator can be moved into the measuring beam for star identification. The oscilloscope shows an out-of-balance pattern.

with a light plexiglas coating to render it moistureproof.

Tests of the iris and its reading mechanism showed them to be quite satisfactory; there is a very smooth, nearly linear relation between magnitude of the star image and iris reading. The iris scale is easily read to the nearest 0.1 degree, and these readings repeat within 0.3 degree. Calibrations show that a single degree on the scale corresponds to 0.01 to 0.05 magnitude, depending upon plate contrast and other factors. Thus one is able to estimate to 0.001 magnitude in some cases, although such results are not significant in view of the much larger emulsion errors.

The plate carriage is attached to the front of the lower member of the framework. Guides for its motion in x and y co-ordinates consist of ½-inch stainless steel drill rods with two brass bearings on one side, and a single ball-bearing roller on the other. The x and y motions are unconventional in employing four strands of the 30-pound nylon fishing line with a tension equalizer. Each strand passes around a portion of the ¼-inch drill rod holding the x and y co-ordinate knobs, and which was turned down to 3/16 inch in diameter. A smoother motion results than that given by a rack and pinion, and there is less backlash. Fastened to the top of the plate carriage is a hinged carrier that holds the clear side of the plate in contact with the extended nosepiece of the upper objective. This resembles the plate carrier used by Eichner. A small spring supplies an upward force of five grams, adjusted with counterweights.

In the picture on page 258, the photometer is seen in operation. The essential controls are grouped within easy reach of the operator's hands near table level. The x and y knobs are evident at the sides of the plate carriage base. Just below, in the center of the base, is the iris control knob, and to the right the lever for shifting from iris inspection to field-viewing illumination. A portion of the plate seven millimeters in diameter is projected on a 6-by-6-inch viewing screen, to permit rapid identification of stars in crowded fields. A projector, attached to the under side of the plate carrier at the right, throws an illuminated crosswire reticle onto a numbered contact print for identifying stars in more sparsely populated fields.

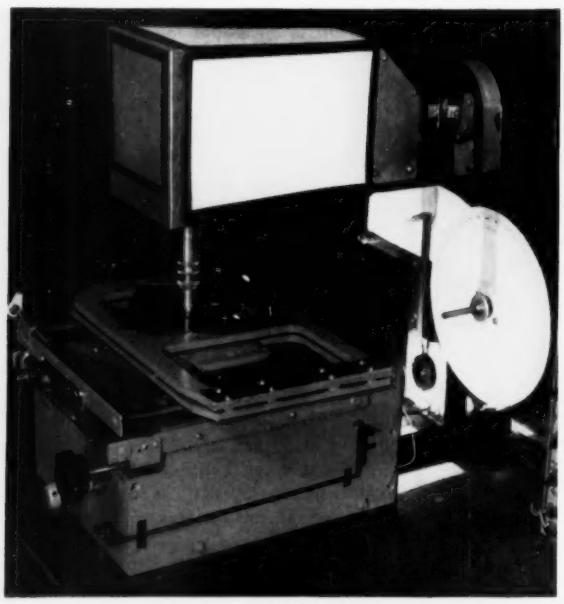


A calibration curve was made from measurements of stars of known magnitude in the globular cluster M53, on a photograph taken with the 100-inch Mount Wilson reflector.

A typical measurement consists of the following operations: The star is identified and brought to the center of the viewing screen; the lever for shifting from field illumination to iris inspection is turned; and the star is carefully centered in the iris image. Then the iris control knob is turned until the oscilloscope indicates balance of the two light beams, and the iris scale is read. With practice, over 100 stars an hour can be measured without difficulty. A switch incorporated into the field-iris lever automatically turns on the chart and iris reading scale illumination at appropriate times.

The photometer has been used extensively for about two years to measure plates taken with the 100-inch Mount Wilson telescope, and the 36-inch reflector of Goethe Link Observatory. The accuracy of measurement was found, as might be expected, to depend strongly on the quality of the image. Round, sharp, well-exposed images about three magnitudes above the plate limit gave probable errors between 0.005 and 0.010 magnitude. Unfavorable images were also tested. Comatic, triangular images, and images near the plate limit, gave greater probable errors, up to 0.016 magnitude. The larger errors arise from difficulty in centering images in the same way each time a measurement is made, and not from inaccuracies in the photometer.

In a typical magnitude calibration chart, as shown here, the curve is nearly linear for the bright images. Moderate curvature appears for fainter images, and increases for the faintest stars as their readings approach asymptotically the clear-plate reading. Decreasing the illumination in the monitor beam enables one to reduce the curvature of the calibration curves for faint stars by diminishing the size of the iris image used. However, increased scatter then appears because of the smaller area over which the photomultiplier averages plate grain.



At the top of this side view of the photometer is the viewing screen, with the housing for the light chopper and the photomultiplier tube. Below and to the left of the circular reading scale is the iris, from which a lever arm projects upward, connected by a fishing line to the drum carrying the reading scale.

VISITOR FROM HOLLAND

Swarthmore College has invited Dr. J. J. Raimond, Jr., director of the planetarium at The Hague, Netherlands, to give a short course in radio astronomy at the Sproul Observatory this spring. He arrived in this country in March, and the course is being completed in April. Dr. Raimond planned to conduct a lecture tour, talking either on radio astronomy of the 21-cm. line or on the Crab nebula, in the last week of March and in April.

Active in both professional and amateur astronomical circles in Holland, Dr. Raimond is chief editor of *Hemel en Dampkring*, the Dutch astronomical periodical, and president of the Netherlands Society for Meteorology and Astronomy. He will return home from New York on May 18th.

MICROFILMS AVAILABLE

Observatories, libraries, and individuals desirous of obtaining microfilm editions of *Sky and Telescope* for volumes IX through XIV may procure them from University Microfilms, 313 North First St., Ann Arbor, Mich. The price for volumes IX, X, and XI is $1.50 each; for volumes XII, XIII, and XIV, $1.60 each. Orders should be sent directly to University Microfilms.

By actual weighing, the great Ahnighito meteorite is now known to have a mass of 34 tons. Photographs by the American Museum-Hayden Planetarium.

THE AHNIGHITO WEIGHS IN

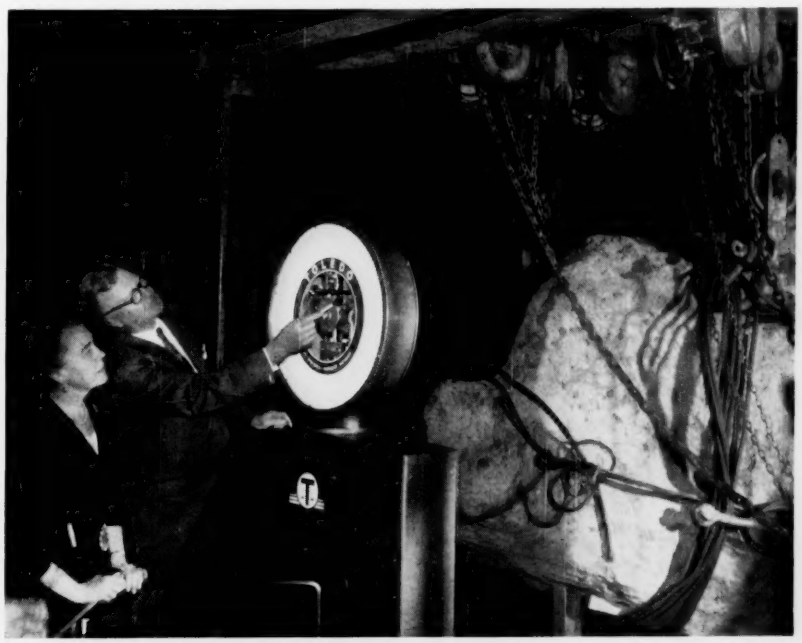
THE LARGEST meteorite on exhibit anywhere in the world is the Ahnighito, at the American Museum-Hayden Planetarium in New York City. This great mass of iron and nickel is 10′ 10″ long, 7′ 2″ high, and 5′ 6″ thick; the only other meteorite known to be larger is the Hoba West, which still lies partly buried where it fell near Grootfontein, Southwest Africa.

How much does the Ahnighito weigh? Until very recently, there were only estimates. Engineers of the Toledo Scale Company designed and built a scale for the specific purpose of weighing the giant meteorite. On February 14, 1956, the Ahnighito was lowered onto the scale, and its weight was read as 68,085 pounds, or a little over 34 tons. Scales and meteorite will form a permanent Hayden Planetarium exhibit, to be opened to the public this month.

Previous estimates of the weight of the Ahnighito had ranged from 36½ to 100 tons. Some of the figures were mere guesses; others were obtained through multiplying the approximate volume by the density of iron—500 pounds per cubic foot—as described by C. C. Wylie in *Sky and Telescope*, November, 1950, page 3. The actual measurement shows the uncertainty of weight estimates of an irregularly shaped mass like the Ahnighito.

The original site of this meteorite was Saviksoah Island, off Cape York in northern Greenland, where Robert E. Peary found it in 1894. Eskimos had for years pounded flakes of iron from the meteorite, for cutting edges of their harpoon points. In 1897, Peary with much difficulty removed the Ahnighito, and brought it by ship to New York.

Two other Cape York meteorites, weighing 1,000 and 2,500 pounds, had been brought to the museum by Peary in 1894. His guide to the sites of the three recovered meteorites told of a fourth, much larger fragment, whose exact position had been forgotten. This fourth meteorite, if it exists, still awaits rediscovery.



Mrs. Marie Ahnighito Peary Stafford, daughter of the explorer and last surviving member of the expedition that brought the meteorite to the United States, watches the weighing-in of the Ahnighito with Warren Hem, engineer of the Toledo Scale Company. Standing on the platform scale, a planetarium visitor will be able to read his weight added to the meteorite's.

Amateur Astronomers

Junior Convention Held in Chicago

ON January 15th the Chicago Junior Astronomical Society was host to a junior convention held at the Adler Planetarium. Eighty-three amateurs from seven junior clubs in three midwestern states registered.

Besides Chicago, other Illinois clubs represented included the Sirius Astronomical Society, the Niles Township Astronomical Society, the Tree Towns Astronomical Club, and the Danville Astronomical Society. Also in attendance were juniors from clubs in Indianapolis, Ind. and Detroit, Mich.

Cecily Resnik, president of the Chicago club, opened the convention and introduced Albert V. Shatzel, assistant director of the planetarium, who welcomed the delegates. Information on each group's activities was exchanged.

Erik Zimmermann gave a paper on making a solar observing screen; Rudolph Schild on the changing sunspots; Robert King on methods of determining the speed of light; and Bernadette Londak on white dwarf stars.

The front cover picture shows Larry Ewing pointing out the equations illustrating the paper he and Keith Cleveland (fifth from the left) gave on the nuclear reactions that produce the sun's light and heat.

The delegates concluded the convention by attending the planetarium lecture, "Skies Down Under," and a special demonstration of the Zeiss projector.

MIAMI CONVENTION NOTES

REGISTRATION for the general convention of the Astronomical League, to be held in Miami July 2nd to 4th, is now open, and a considerable saving can be effected by delegates who register promptly.

Until May 1st, the registration fee will be $1.00 per person; from May 1st to July 1st, inclusive, it is $2.00; and on July 2nd, when the convention formally opens, it becomes $3.00. Until July 1st, however, the registration for an entire family will be only $3.50; family registration rises to $5.00 on July 2nd.

Checks for registration should be made payable to the Miami Astronomical Convention Committee and mailed to the Astronomical League Convention, c/o McAllister Hotel, Miami, Fla. Hotel reservations can be sent at the same time, but need not be.

The convention headquarters will be at the McAllister, which is the third largest hotel in Florida, and is situated at Biscayne Blvd. and Flagler St. The minimum hotel rates are $5.00 per day single, $7.00 double, and $3.50 per day per person in dormitory-type family rooms holding four to eight people. These special rates will prevail for the delegates for a week before and after the convention.

On Sunday, July 1st, there will be a meeting of the council of the Astronomical League, exhibits will be set up, there will be an informal get-together for early arrivals, and a registration desk will be open.

At the opening convention session, scheduled for 10:30 Monday morning, the executive secretary, Wilma Cherup, will conduct the annual roll call of societies. Brief written reports should be sent to her for this purpose and for inclusion in the *Proceedings* of the convention. There will be reports of officers and section chairmen. Papers on lunar and planetary observing will be given early Monday afternoon, followed by the group photograph at about 3 p.m. Then Dr. Harlow Shapley will be the chief speaker in a session on the frontiers of astronomy. There will probably be field trips to local observatories on Monday evening.

The meeting of the Southeast region will be held Tuesday morning, July 3rd. A session for papers on observing will begin the day for the general convention, followed by election of officers and reports of regional chairmen. A high point of the program will be reached on Tuesday afternoon, when G. R. Wright will be chairman for a session on observing the artificial satellite. Later, there will be a period for talks by junior astronomers. The Astronomical League award will be made at the convention banquet, and a star party, with the public invited, is scheduled for later that evening.

Wednesday's program includes a panel discussion on club projects, and one or two sessions on instrumentation. The convention will adjourn during that afternoon, and exhibits will be dismantled.

Thursday morning may require early rising by many delegates, if plans for a trip to Key West materialize, possibly to be followed by a trip to Havana and other points in Cuba. These proposed excursions would occupy their participants until July 7th or 8th.

AMATEUR MEETINGS IN MAY

On May 18-20, the Northeast region of the Astronomical League and the American Association of Variable Star Observers will hold meetings within 60 miles of each other. The first will take place at Colgate University, Hamilton, N. Y., and the second at Cornell University, Ithaca, N. Y.

Further information about the regional convention at Hamilton may be obtained from the secretary of the Northeast region, James B. Kaler, Valley Lane, McKownville, N. Y. Details of the AAVSO program at Ithaca can be procured by writing the society headquarters at 4 Brattle St., Cambridge 38, Mass.

The skyline of the city of Miami is a glittering spectacle at night.

THIS MONTH'S MEETINGS

Chicago, Ill.: Chicago Astronomical Society, 8 p.m., Adler Planetarium. April 13, Dr. Philip Barnhardt, Perkins Observatory, "Discrete Sources."

Cleveland, Ohio: Cleveland Astronomical Society, 8 p.m., Warner and Swasey Observatory. April 13, Dr. S. W. McCuskey, Warner and Swasey Observatory, "The Composition of the Milky Way."

Des Moines, Iowa: Iowa Division, Great Plains Astronomical Society, 2:30 p.m., Drake Municipal Observatory. April 15, Robin Bruner, "Meteoric Origin of Lunar Formations."

Detroit, Mich.: Detroit Astronomical Society, 2:30 p.m., State Hall, Wayne University. April 8, Dr. Helen Dodson, McMath-Hulbert Observatory, "The Sun."

Geneva, Ill.: Fox Valley Astronomical Society, 8 p.m., City Hall. April 10, William Sickman, Jr., "Meteor Showers—Wet Ones."

Long Beach, Calif.: Excelsior Telescope Club, 8 p.m., Menifee Valley Observatory. April 14, star party, Thomas A. Cave, Jr., "Preview to Mars."

Lorain-Elyria, Ohio: Black River Astronomical Society, 8 p.m., Elyria YWCA. April 18, Joseph Sandbote, "Astronomy in Navigation."

Marietta, Ohio: Marietta Astronomical Society, 7:30 p.m., Cisler Terrace. April 29, Dr. John E. Sandt, Marietta College, "The Expanding Universe"; Dr. Warren G. Steel, Marietta College, "The Planet Earth."

Montreal, Canada: Montreal Centre, Royal Astronomical Society of Canada, 8:15 p.m., Macdonald physics building, McGill University. April 12, E. E. Bridgen, "Our Stellar System and External Stellar Systems."

New York, N. Y.: Amateur Astronomers Association, 8 p.m., American Museum of Natural History. April 4, motion picture, "The Story of Palomar."

Springfield, N. J.: Amateur Astronomical Society of Union County, 8 p.m., Regional High School. April 27, Joseph M. Chamberlain, Hayden Planetarium, "New Man-Made Earth Satellites."

Washington, D. C.: National Capital Astronomers, 8:15 p.m., Commerce Department auditorium. April 7, Dr. Milton W. Rosen, Naval Research Laboratory, "Project Vanguard—Placing the Satellite in Its Orbit."

ST. PETERSBURG, FLA.

The State of Florida has appropriated funds for the addition of a science building at the junior college in St. Petersburg. To help the college obtain a 16-inch reflector for the planned observatory and a projector for a proposed planetarium, the St. Petersburg Astronomy Club has embarked on fund-raising activities. Included among these was a public showing of the film, "Looking Through the 200-inch and Other Great Telescopes," with the accompanying lecture by Dr. Ruroy Sibley, a member of the club.

OHIO TURNPIKE AMATEURS

Completion of the Ohio Turnpike, which has considerably reduced travel time between parts of that state, prompted four astronomical societies to meet informally on January 25th, at the Great Lakes service plaza on the new highway. Representatives came from the Black River Astronomical Society of Lorain-Elyria, the Astronomy Club of Akron, the Mahoning Valley Astronomical Society of Warren, and the Youngstown Astronomy Club.

The idea for this group gathering, informally called the Ohio Turnpike Amateur Astronomers, originated with Kenneth Walker of the Black River society, when he realized the closeness of the four societies because they are located near the turnpike. His society set the time and place of the January meeting, which was so successful that two more are planned. On May 12th, a get-acquainted meeting will be held in Akron, when each society will present a survey of its activities, membership, equipment, and future programs. Another conference will be in August.

WHITTIER, CALIF.

Entering its third year of activities, the Whittier Astronomical Society plans an extensive program for observing Mars and the two main meteor showers this summer. An 8-inch, f/12.5 Springfield reflector will be the principal instrument used for Mars, in addition to several 6-inch reflectors and a small refractor. This society wishes to hear from other amateur groups to compare their Mars observations and summer meteor rates.

Our members are also working on five 6-inch telescopes and a 4-inch off-axis reflector, while a 10-inch is planned. Telescope making facilities are being set up in a member's basement, which doubles as a lecture room.

During previous years, the society acquired considerable experience in observational astronomy and meteor work. In 1954 over 4,000 meteors were plotted at Lake Arrowhead and at a five-acre site near Twentynine Palms, which was purchased as a permanent observing station. In 1955 several members undertook to study all of the Messier catalogue objects.

This society is a member of the Astronomical League.

RICHARD N. STURTRIDGE
8416 Davista Drive
Whittier, Calif.

MIDDLE EAST CONVENTION

Dr. Joseph Kaplan, chairman of the U. S. National Commission for the International Geophysical Year, will be principal speaker at the Middle East regional convention of the Astronomical League on May 4-6 at Washington, D. C. Dr. Kaplan will talk on "The International Geophysical Year and the Space Frontier."

Convention headquarters will be in the Department of Commerce auditorium, at 14th St. and Constitution Ave. N.W. Activities planned include a color motion picture on electronic calculators, an observing session, and reports on instruments. The National Capital Astronomers will be host to the convention. Miss Mabel Sterns, 1833 New Hampshire Ave. N.W., Washington 9, D. C., is head of the convention committee.

A new feature on the schedule of such a convention is a session for adults working with juniors.

ALPHA HERCULIS

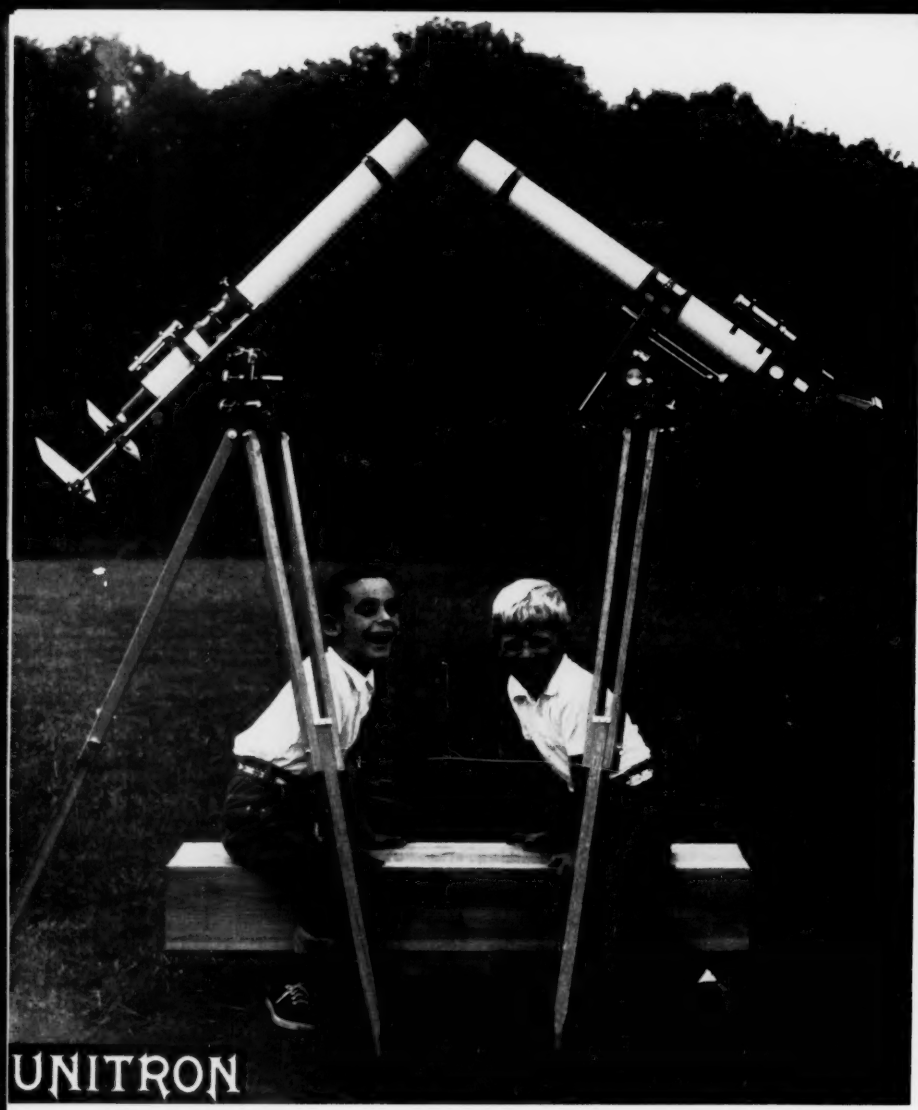
(Continued from page 254)

ionization of the shell depends on whether the supergiant is a single star or a binary. If the companion is very hot, as in Antares, the shell is highly ionized and we observe the emission lines of ionized iron produced in the shell. If the star is single, as in Betelgeuse, the ionization is low and corresponds to the temperature of the reversing layer of the supergiant itself.

It is probable that in the long-period variables the gaseous material expelled by the star undergoes at times condensation into solid or liquid particles. These would drastically reduce the light of the central star, as explained in my article on Mira Ceti (*Sky and Telescope*, September, 1954, page 368). These considerations need revision, however, in view of Deutsch's determination of the approximate size of the shell and its relative "emptiness."

Previous calculations of the condensation process assumed that the shell is uniformly at a pressure of about 10^{-12} atmosphere and a temperature of 2,000° absolute. According to Deutsch, only the denser clouds inside the shell contain 10^{10} atoms per cubic centimeter; therefore we can assume a temperature of 2000° in applying the perfect gas law to find a pressure of 3×10^{-9} atmosphere.

This pressure is much larger than is required for the condensation of carbon gas into soot. But the gaseous shell of Alpha Herculis consists mostly of hydrogen, and the partial pressures of those constituents that are capable of condensing may not be very different from the values previously considered by John O'Keefe and others, for the smoke clouds of such stars as R Coronae Borealis and Mira Ceti. Thus it seems likely that the light variations of Alpha Herculis are caused by changes in veiling within the gigantic shell studied by Deutsch.



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See page 281 and the back cover.

Both 2.4" models come complete with tripod and mounting, eyepieces, view finder, sunglass, choice of UNIHEX Rotary Eyepiece Selector or erecting prism system and star diagonal, and cabinets for tube and tripod.

Model 114 with altazimuth mounting and slow-motion controls for both altitude and azimuth, eyepieces for 100x, 72x, 50x, 35x. ($31.00 down)

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Model 128 with equatorial mounting and slow-motion controls for both declination and right ascension, eyepieces for 129x, 100x, 72x, 50x, 35x. ($56.00 down)

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Erecting Prism System	18.50
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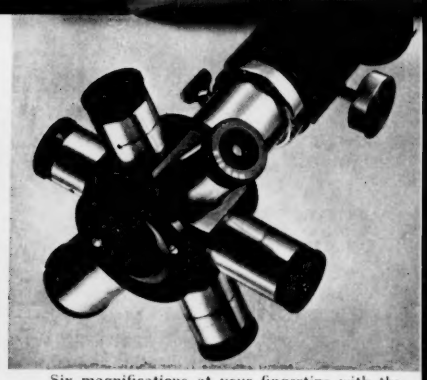
5-mm. (180x) Orthoscopic Eyepiece	14.75
6-mm. (150x) Orthoscopic Eyepiece	14.75
7-mm. (129x) Achromatized Symmetrical Eyepiece	9.75
40-mm. (22x) Kellner Eyepiece	14.75



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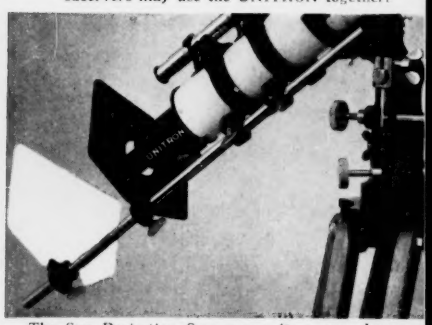
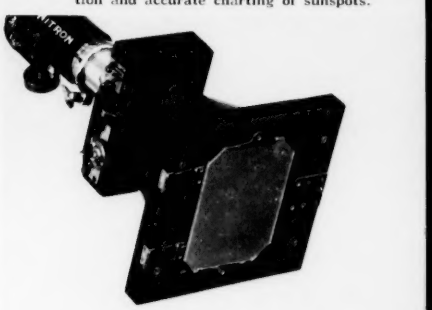


The Sun Projecting Screen permits group observation and accurate charting of sunspots.



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BOOKS AND THE SKY

THE MOON

H. P. Wilkins and **Patrick Moore.** The Macmillan Co., New York, 1955. 388 pages. $12.00.

UNTIL NOW, if you wanted a book in English that gave a complete and detailed description of the moon's visible surface, there were the classics by E. Neison (1876), T. G. Elger (1895), and by W. Goodacre (1930). All three are long out of print and hard to find, and moreover outdated by the activity of recent observers. The appearance of a new book of this class by two of the best-known British amateur students of the moon is particularly welcome.

Each author has recently published a smaller and more popular book on our satellite: Moore's *A Guide to the Moon* was reviewed in the March, 1954, *Sky and Telescope*, and Wilkins' *Our Moon* in the January, 1956, issue. These more general accounts are needed to supplement their joint treatise, which despite its size is almost entirely confined to topography.

The greater part of *The Moon* consists of systematic descriptions of about 800 of the most important craters, mountains, and seas. These accounts range from a few lines up to three pages for major formations like Plato, and they are often accompanied by drawings or charts. There are also photographs of exquisite quality obtained by the late B. Lyot at the Pic du Midi, and by E. A. Whitaker with the Greenwich 36-inch reflector. Mr. Whitaker has also contributed a very valuable 10-page appendix on the principles and methods of lunar photography.

These descriptions include numerous minute details added through very recent observations, many by the authors as visiting observers with the 33-inch refractor at Meudon. This has meant crowding out some important older results, but as the writers point out, "Every effort has been made to render this work supplementary to other books, and not a mere repetition of already recorded observations."

It is unfortunate that each account of a lunar formation does not have its own list of references to published descriptions and drawings. The serious observer has to consult original publications and find what his predecessors have done, or he risks wasting his time by repeating what was carried out more thoroughly in the past. This is particularly important for major craters like Plato, on which hundreds of pages have been written, which are available in large astronomical libraries if only one knows where to look. It would be a very great service to selenography if the Lunar Section of the British Astronomical Association, or the Association of Lunar and Planetary Observers, would compile and publish a collection of crater bibliographies.

A valuable feature is the reproduction on a reduced scale of Wilkins' 300-inch map of the moon, in 25 sections, and with the addition of some recent revisions. The new scale of about 16 inches to the lunar diameter is sometimes inconveniently small, particularly in the crater-rich southern regions, as some 90,000 features in all are plotted!

The crater nomenclature in this book needs mention. Many names have been introduced by Wilkins and used in the text and map without distinguishing them from other names internationally accepted. Appendix II lists new designations for 99 features, of which about two dozen were previously nameless, but the others are already listed in Blagg and Müller's *Named Lunar Formations* (1935).

The authors fail to make it clear that the new names are actually only proposals that do not have official standing until approved by the International Astronomical Union. A number of the new crater designations proposed by Wilkins are intended to honor astronomers of the first rank. But it is rather surprising that a ring plain over 100 miles across should be christened Hörbiger, after an Austrian writer of the Velikovsky type.

The history of selenography plays an

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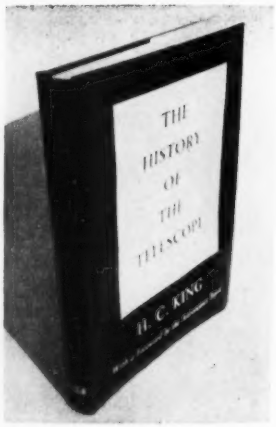

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important part in the introduction and appendixes of the book. There is an interesting collection of brief biographical sketches of lunar observers, past and present. The important Prague selenographer, Ladislaus Weinek, ought to have been included here.

Wilkins and Moore's *The Moon* will undoubtedly be for years to come the standard reference work on detailed configuration of the lunar surface. However, the authors' viewpoint is a narrow one. They are concerned primarily with filling in minute detail by direct visual observation, or from inspection of photographs. Mathematical selenography is slighted; you will look in vain for information on how to measure the longitude and latitude of a feature, or for a quantitative account of the moon's libration, but an appendix does give formulas for finding the height of a mountain from the length of its shadow.

Other methods of observation than simple inspection are little mentioned, notably lunar photometry. The variation of brightness of lunar formations with changing illumination is a field in which valuable work has been done by the professional, and to which the advanced amateur can contribute. It would have been useful to have discussed colorimetric and polariscopic techniques and what has been learned from them. Measurements of radiation at infrared and radio wave lengths during lunar eclipses tell us of a thin dust layer coating the moon. All these are aspects of the growing science of selenophysics, which bears the same relation to selenography that geophysics does to geography. It can no longer be neglected in an intelligent attack on the problem of how the moon's surface evolved.

This attack requires the special skills and the physical insight of professional astronomers, and the detailed description of the moon's surface that amateur astronomers are providing. What the amateur has contributed to this joint effort is epitomized in *The Moon*.

J. A.

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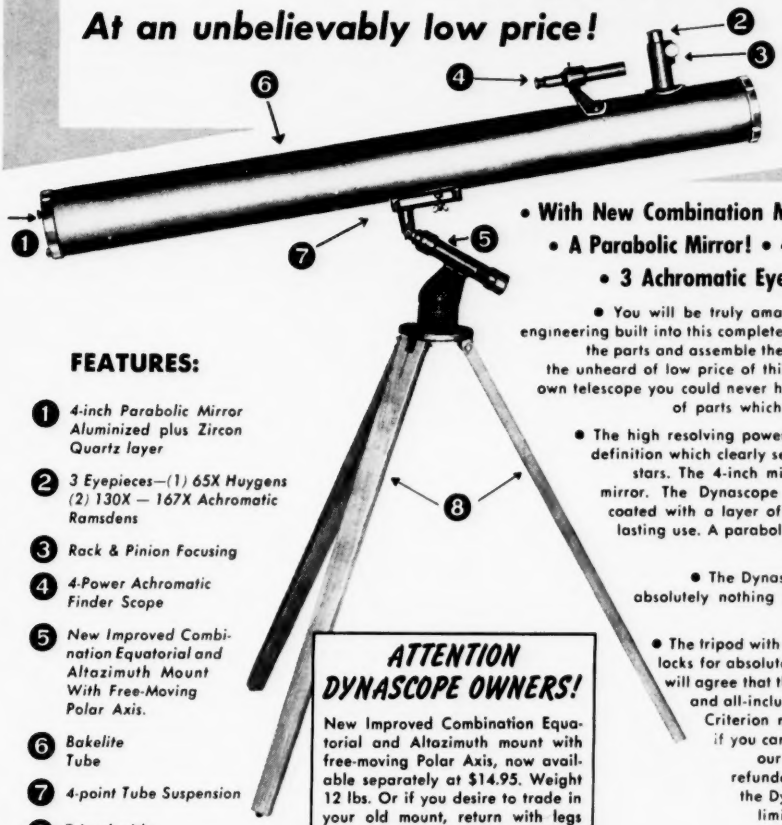

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THE CARE OF FINE OPTICAL SURFACES

A century from now, in 2054, your Questar should be in the prime of life, and good, perhaps, for another hundred years. In closing this booklet with some words on the care of optics, we had this thought—that the purchase of a telescope is in reality the selection of an heirloom, for fine instruments are made to weather time. Perhaps it is only fitting that the kind of thoughtful person who would own a telescope should be remembered by an instrument of such historic importance in mankind's quest for knowledge.

To preserve optical surfaces for any length of time, it is only necessary to see that the surface is not damaged. The greatest source of damage to the lenses of optical instruments is said to be due to overzealous owners who cannot bear to touch them without vigorously shining up the glass. It goes without saying, that an instrument should be kept in its case, or somewhere out of the dust, but dust itself does not hurt glass until someone starts to rub it off, and makes it act like sandpaper.

Dust is everywhere, and a large part of it is tiny grains of sand, harder by far than optical glass, because it is actually quartz. To clean off a dusty lens with a handkerchief is to rub the sharp little quartz crystals into the optical surface, neatly plowing tiny furrows. This kind of damage is irreparable, for a network of thousands of tiny scratches will lay a fog upon the image, whereas one big bold scratch does no perceptible damage to performance at all.

Beauty defects, as they are known to the trade, are a headache at best to opticians. A floating dust mote from the air may cause a single sleek or scratch during the last strokes of final polishing. Minute bubbles, pits or edge chips, too often cause the rejection of an otherwise perfect lens that may represent a great number of dollars in labor alone. The great Fraunhofer, who made the best refractors of his time, was once reproached by a patron for a defect in a surface. "Sir," replied the master, "this glass is to be looked *through*, not at."

So, the way to preserve a fine optical surface is to restrain as best we can our natural desire for cleanliness. Since we cannot avoid the presence of a little dust, perhaps it is wise to learn to live with a bit of it. The thing is, let's not keep polishing the front lens and eye lens every time we use our instrument. Internal surfaces may go untouched for years.

The secret of cleaning lies in getting the grit off before rubbing, then rubbing as little and as lightly as possible. Brush the grit off with the softest little brush obtainable. Then use cotton, or facial tissue fresh from the box (unfold it and use the inside!). Or a soft clean piece of old cotton cloth. If you can breathe on the lens without droplets, a fog of distilled water is condensed from your breath. To avoid leaving lint, breathe on the tissue or cloth too, a useful wrinkle. Lens tissues should be avoided like the plague for anything better than the cheap lenses of spectacles, since they just invite you to commence rubbing. Eyeglass cleaning fluid, however, which is sold under various names, is excellent for removing finger marks whose acids can quickly hurt the coated surface. But get the dust off first.

Questar's glass surfaces, each of which would normally lose some 4½% of light by reflection, are coated with a layer of magnesium fluoride 5 millionths of an inch thick. This shows as a faint purple-bluish tint, reducing reflection loss at each air-glass surface to less than 2%. The net gain in contrast and brilliance is some 25%. The hardest coating available to date will still scratch and rub off eventually. So dust off with soft brush sparingly, and use water and cloth only once or twice a year if you can't resist the polishing impulse.

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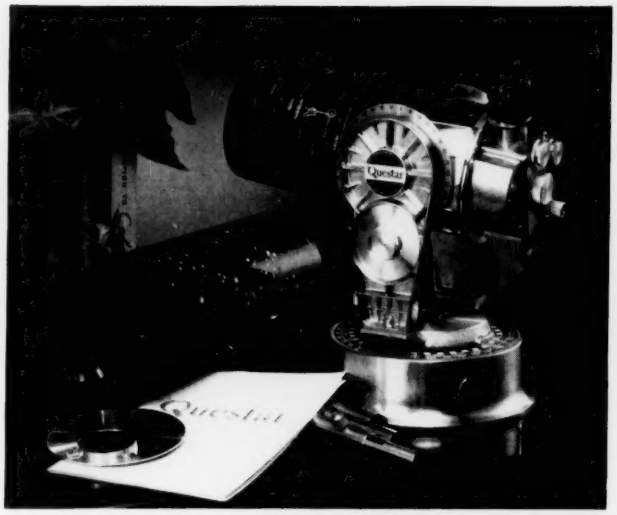
There are, of course, a few pretty obvious don'ts to mention in passing. Extremes of temperature or humidity should be avoided. Don't put a telescope away in summer soaking wet with dew, or store it in a sizzling attic or damp cellar. Too much dry heat may affect the balsam of cemented eyepiece lenses. Heat and humidity can breed the fungi that etches glass, as we learned in the South Pacific war. On a cold winter's evening any glass and metal object is likely, after being brought back indoors, to frost up like an iced drink in August. Just let Questar warm up and get dry before putting it into the case. Probably the only optical instruments that should be used continually at the seashore are the sealed type of marine binoculars, expressly developed for salt atmosphere. Doubtless Questar's metals, like any others, would profit little from extended exposure to the corrosive salt-spray of the ocean.

In conclusion, we should remember that all over the world fine microscopes and telescopes more than a century old are still working beautifully. Questar should exceed their useful life with only ordinary care. A nice thought, too. What other of man's engines is built with such a life expectancy? Our thoughtful care may some day thus give pleasure to our great-great grandchildren. THE END

This concludes the reprint of the Questar booklet, a copy of which is available upon request.



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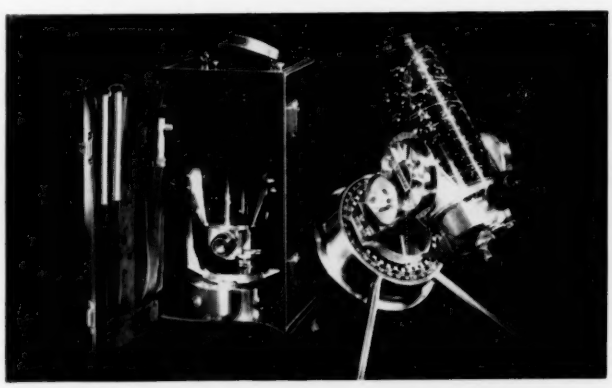

square year, and megalosaros, each containing an integral number of lunar synodic months, nearly commensurable with an integral number of draconic (nodical) half-months.

The author goes into great detail about the *inex*, a period of 358 lunations, which is mentioned briefly in chapters on eclipses in general astronomy textbooks, although not, to my knowledge, by this or any other name. He has derived it from *in* and *ex* (in and out), as it is the average interval between initial eclipses in two new saros series or the final ones in two old series. In other words, when a new solar saros begins with a small partial eclipse near one of the poles, the next new series commences 358 lunations later, or after an interval of 29 years less 20 days.

The inex is 388.50011 draconic months, so that consecutive eclipses occur near alternate nodes of the moon's orbit. The shift of the moon and the sun with respect to the nodes is extremely small from one inex eclipse to the next. Accordingly, an inex series lasts about 23 thousand years, whereas a saros is only 12 or 13 hundred years in length.

Characteristics of succeeding eclipses are well presented graphically by the use of a saros-inex panorama, in which the events in a vertical column belong to a given saros, while those in a horizontal row belong to a particular inex. The book is in two volumes, and the second is entirely a compilation of charts that illustrate various aspects of this saros-inex panorama for solar and for lunar eclipses. The first volume contains the text and a chronological listing of the eclipses in Oppolzer's *Canon der Finsternisse*, together with type, magnitude, duration, and so on, for each eclipse.

The work contains much of interest about borderline eclipses, such as non-central umbral solar ones, in which the axis of the moon's shadow does not actually pierce the earth's surface; hybrid eclipses, which are total near the middle of their paths but annular near the ends at sunrise and sunset; and partial solars that would occur were it not for the flattening of the earth at the poles.

Considerable analysis is made of the relative numbers of the various types of eclipses and the conditions required to produce them. An example is the ratio of the number of total to annular solars and the influence of various factors such as the elliptical orbits of the moon and earth. The author makes note of the long-period or secular changes in the moon's motion, such as the gradual shortening of the synodic and anomalistic (perigee-to-perigee) months. Very little is written about the interrelation of solar and lunar eclipses, such as the types of each to be expected in a given synodic month, the numbers of each in a year, and so on.

There is not much included on penumbral lunar eclipses, but the reviewer was pleased to read a brief reference to them, in which it is pointed out that they are about as frequent as partial solar eclipses. The analogy between an umbral lunar eclipse (whether partial or total) and an umbral solar one, insofar as ecliptic limits and relative occurrence are concerned, is noted.

Professor van den Bergh has done a commendable piece of work in compiling and analyzing these data. Extensive study is required to master all the details of his work, and a careful reader might be able to discover other interesting repetitive patterns from the charts and tables. The book would be of greater service if a glossary and index had been included.

PAUL W. STEVENS
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Leon Campbell. American Association of Variable Star Observers, Cambridge, Mass., 1955. 247 pages. $6.00 cloth, $5.00 paper.

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for each star, between 1921 and 1949. The next set of data comprises the mean light curves for all of the variables, but these are drawn freehand, giving only a schematically accurate illustration of the brightness variation in each case. In the last section of the book we find a collection of characteristics of each star's light curve that broadly express its shape.

The observations on which this book is based, several hundred thousand in number, were obtained by the members of the American Association of Variable Star Observers. The society's present recorder, Mrs. Margaret W. Mayall, prepared the manuscript for publication, taking up where Mr. Campbell left off when he died in 1951.

Except for one or two diversions, the contents of this book provide us with unembellished basic visual data on the most common variable stars of late spectral class. These objects have kept their true nature well disguised, and in the present era of meticulous study of peculiar individual stars, even the thought of producing observational records for hundreds of stars would appear forbidding and would demand an intrepid spirit. The book has been made possible only by the long-continued observations of hundreds of enthusiastic amateur observers.

The importance of this work lies in its richness of material that can be used for further research on a special group of Milky Way stars, the still mysterious red variables.

SERGEI GAPOSCHKIN
Harvard College Observatory

NEW BOOKS RECEIVED

THE SUN AND ITS INFLUENCE, *M. A. Ellison*, 1955, *Macmillan*. 235 pages. $4.50.

A British solar expert summarizes what is known today about the sun, and about terrestrial phenomena, such as auroras, that are due to solar activity. The book is nonmathematical and is suitable for the informed amateur.

A GALLERY OF SCIENTISTS, *Rufus Suter*, 1956, *Vantage*. 132 pages. $3.00.

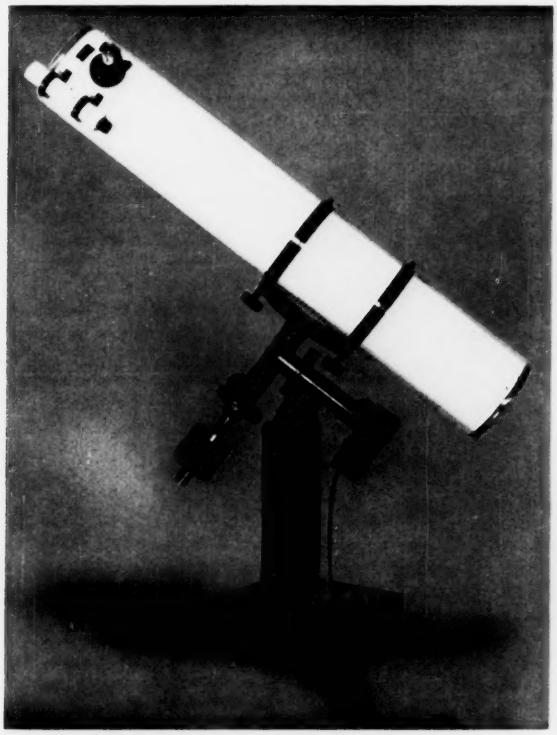
This anthology describes the significance of ten great men of science, from Aristotle through the centuries to Hume, Watt, and Kant. Each sketch originally appeared in magazine form; "Galileo in Padua" was first printed in *Sky and Telescope*, November, 1951.

THE NEW ASTRONOMY, edited by *Scientific American*, 1955, *Simon and Schuster*. 243 pages. $1.00, paper bound.

A collection of 20 popular articles, originally published in *Scientific American*, covers such topics as the structure of the universe, interstellar matter, our galaxy, stars, the solar system, and radio astronomy.

RECENT ADVANCES IN OPTICS, *E. H. Linfoot*, 1955, *Oxford University Press*. 286 pages. $8.00.

This account of the chief developments in instrumental optics during the last 20 years deals with theoretical aspects rather than practical techniques. Among the subjects considered are the optical properties of Schmidt and Schmidt-Cassegrainian telescopes, and the diffraction theory of the Foucault knife-edge test. The volume is one of the *International Series of Monographs on Physics*.



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The telescope is portable — weighing about 85 pounds. It may be dismounted or assembled in about three minutes, making it convenient for transporting and storing. The mirror and diagonal are of pyrex, aluminized and quartz overcoated, optically good to ⅛ wave length and guaranteed to resolve doubles to Dawes' limit on good seeing nights.

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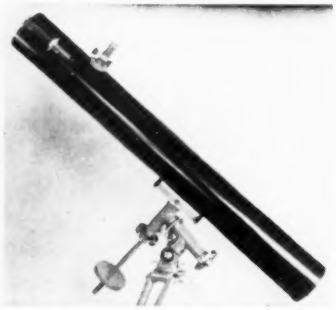

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Pictured here is our eyepiece attachment with rack-and-pinion assembly smoothly machined from solid aluminum castings. Main tube is 1¾" long; sliding tube adds 2" more; total movement 3¾". Gray or black crinkle finish.

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GLEANINGS FOR ATM's

EDITED BY EARLE B. BROWN

The Youngstown Astronomy Club 16-inch Cassegrainian

IN AUGUST, 1949, a note and pictures were published in *Sky and Telescope* showing the start of the 16-inch Cassegrainian project of the Youngstown Astronomy Club. Now the instrument is in operation, after many years of hard work by many members of the society. Some of them are shown here with the instrument, and the telescope shelter is rolled out of the way.

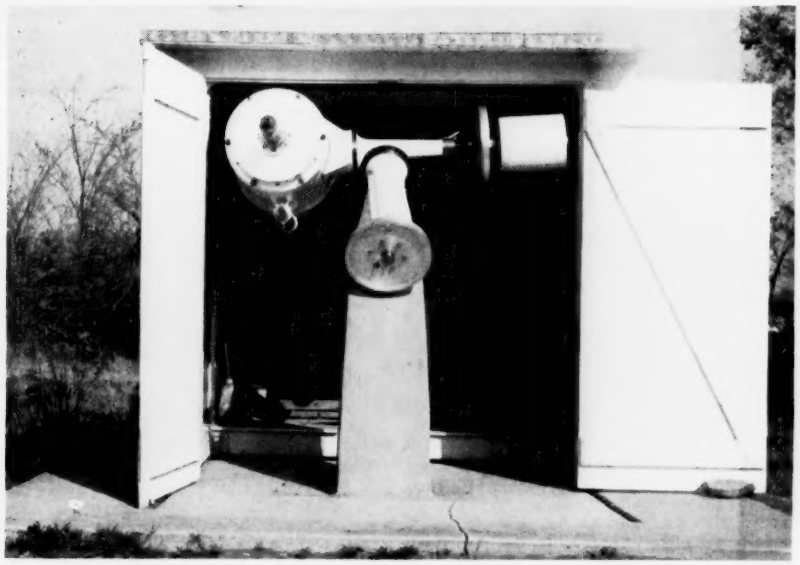
The mirror was edged and then roughed out with a grinding wheel. It was surfaced with a cast-iron lap and turned over to one of our members, T. G. Beede, an expert with 57 years of telescope making experience. He also made the secondary mirror. In this optical work he was assisted by Charles Prather. The mechanical work was chiefly carried on in my home workshop.

Situated in a good location on the outskirts of Youngstown, the telescope is housed in a roll-away type of building. The foundation for the housing is a slab of 8" concrete, with a pier for the telescope in the center of the larger half of the slab. The pier makes no contact at any point with the foundation, extends six feet deep and sets in a bed of sand. The sand allows rapid drainage of water and acts as a shock absorber for ground tremors. The pier is also wired internally to carry electricity to the instrument. The house rolls on two rails embedded in the concrete. When the telescope is covered, the shelter locks to the pier from the inside, so the building cannot be moved.

The pyrex mirror blank was originally three inches thick. The primary focal length is 80", but the amplification is 3.12, giving an equivalent focal length of 250", quite suitable for a Cassegrainian. We recently used 1,000 power on this instrument without breaking down the image.

Several members helped with the pattern making. Major castings were made of iron, smaller ones of aluminum. The 2½" polar axis turns in bronze sleeve bearings lapped to fit. The large flange at the junction of the polar axis and the

Members of the Youngstown Astronomy Club with their new telescope. Left to right: Arnold Habuda, Leo F. Grandmontagne, David Duff, Anthony Luszcz, T. G. Beede, Robert Brook, Cyrill Mattis, and Peter Wenzen.



Here the 16-inch is partially covered by its sliding building.

declination axis tee, also the flange at the tube saddle, provides the rigidity which is necessary for good smooth motion in a mounting of this size.

The polar axis has a friction clutch system that uses the worm gear as the clutch plate. One side of the gear rests its full face directly against the declination axis tee, but the side of the gear that comes in contact with the flange at the top of the polar axis housing is kept from making full contact by a ring of ball bearings. Thus, since the friction is greater on the declination axis side, movement of the worm gear tends to move the whole telescope. Yet the instrument can readily be turned by hand to a new setting without damage to the driving train of gears. Any desired amount of tension can be applied by tightening the nut located at the south end of the polar axis.

The 16-inch setting circles were made by Haines Scientific Instruments, Englewood, N. J. The counterweight was made from a five-gallon can filled with 220 pounds of boiler-plate punchings and just enough cement to hold them in place.

An unusual feature is the design of the secondary support, which has only two vanes, placed at about 120° to each

The secondary support has only two vanes, to reduce diffraction effects.

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All eyepieces have hard-coated optics and come with metal dust caps. Telestar eyepieces are of the bayonet type and lock securely into an adapter tube with just one-quarter turn. They are made in 11mm., 16mm., and 22mm., focal lengths. All metal parts are black, anodized aluminum.

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Diameter	Plate-Glass Tool	Pyrex Tool
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other. These are seen best in the closeup view of the upper ring of the telescope tube. This design spreads secondary-support diffraction around the star image, and the images of stars look more nearly like points of light. The support is very light, and the position of the convex secondary mirror is adjustable to and fro; it can also be tilted in any direction without moving off center.

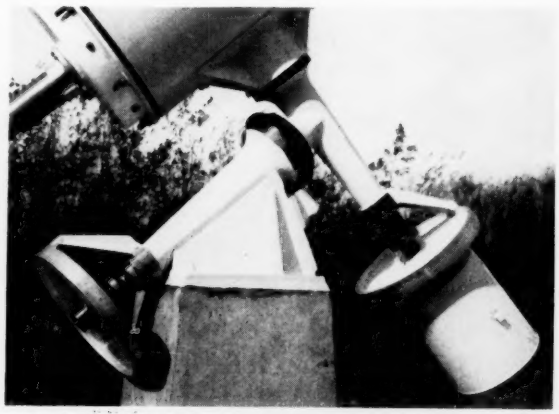
We shall be glad to hear from other amateurs and societies who wish further details about the construction and cost of this instrument.

LEO F. GRANDMONTAGNE
199 Wychwood Drive
Youngstown 12, Ohio

CONTROLLING AN ELECTRIC DRIVE AT THE CLOCK

SOME YEARS AGO I made a driving mechanism to run my telescope at the solar rate of one complete rotation in 24 hours. This was described in this column in December, 1949. It consists of a Telechron motor of four revolutions per minute geared down to a worm that turns four revolutions per hour. This engages a worm gear of 96 teeth that is connected to the polar axis by a pressure clutch.

When I work with stars, however, this drive needs constant correction, for the sidereal rate differs from the solar by four minutes a day or 10 seconds an



Rugged yet precise construction is evident in every detail of the Youngstown 16-inch mounting. Heavy flanges on both axes take the instrument's weight easily and provide smooth, steady motions. Friction for the declination axis is provided by a heavy spring just above the declination circle. The pointer arms for the setting circles are large and well placed for easy reading.

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Illustrated here is the 16-foot dome of the Greenwich, Conn., High School Observatory before and after an ASTRO-DOME was constructed. The first picture shows the original crude shutter system, which was difficult to operate. It took almost 10 minutes to open the shutter and even required climbing tall ladders! ASTRO-DOME replaced the old shutter and widened the slit aperture from 30 to 48 inches. Alden W. Smith, head of the astronomy department, claims that the new slit system actually has made the dome far stronger.

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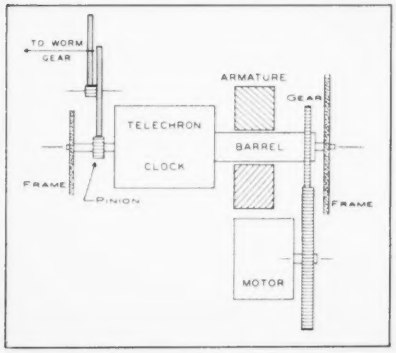
hour. I have been able to arrange my Telechron clock in such a way that a constant correction of 10 seconds per hour can be imparted by an auxiliary motor, or this can be disconnected and the speed of the drive controlled manually simply by turning the Telechron clock barrel around its axis of support. The diagram shows the arrangement.



The Telechron clock of Luc Secretan's telescope drive is supported by pivots in the frame. The auxiliary motor is in the lower right.

The armature has been opened a little, so the barrel can rotate freely within it. The clock is thus supported at two pivots in the sides of the frame that holds the clock and gears. With this free-floating arrangement, running the clock would turn the motor barrel backwards, while the gear train would be standing still. However, when the barrel is prevented from turning, the rotation of the pinion is transmitted to the telescope through the gear train.

At the right of the barrel I have attached an additional large gear, which is engaged by the one below it that is driven by the auxiliary motor, which thereby controls the movement of the barrel. The amount of rotation of the barrel required to correct 10 seconds per hour depends on the construction of the planetary gear inside the Telechron motor. In my case a corrective rotation of two revolutions per hour is required to obtain the desired sidereal rate of 23 hours, 56 minutes. This was easily accomplished with an auxiliary motor speed of one revolution per hour and a gear ratio of 1 to 2.

When the auxiliary motor is running, the telescope tracks with sufficient accuracy to permit good photography through a lens of five centimeters focal length without requiring much attention. However, for focal lengths of 20 inches or longer, manual correction may be necessary. In that case, the auxiliary motor can be swung out of mesh and the clock barrel manipulated by hand to maintain the guide star on the crosshairs.

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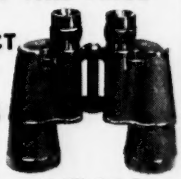

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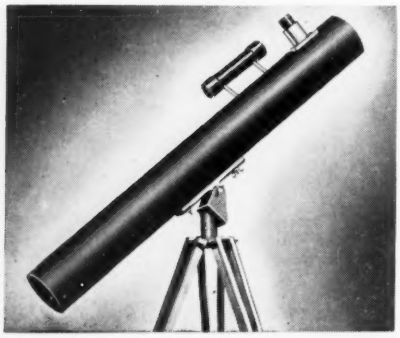

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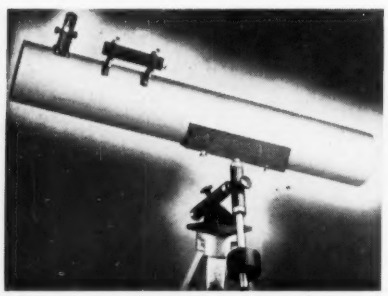
40X, 60X, 120X, 150X, 300X



Complete with heavy duty equatorial mounting and tripod. Tripod has cast aluminum head and rugged wooden legs for stability. (Folds for storage.) Equatorial mount has 1" diameter shafts with Boston bronze bearings. 5-lb. counterweight for perfect balance. Locks on both declination and polar axes. Polar axis set at 40°; latitude adjustment made with tripod legs. Black crinkle finish on mount. Telescope tube made of aluminum; white enamel finish on outside. Rack-and-pinion focusing eyepiece mount. 7X achromatic finder with crossline reticle. 6" Pyrex parabolic mirror—48" F.L. (f/8)—aluminized and overcoated—guaranteed to give theoretical limit of resolution. Mirror mount machined cast aluminum. Kellner eyepiece gives you 40X and a Goto combination eyepiece gives 60X and 120X. A Barlow lens is included to give 150X and 300X. Shipping weight 75 lbs.

Stock #85,024-Y **$245.00 f.o.b.**

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Your Chance to Pick Up an Excellent Bargain

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M-17 8-POWER ELBOW TELESCOPE

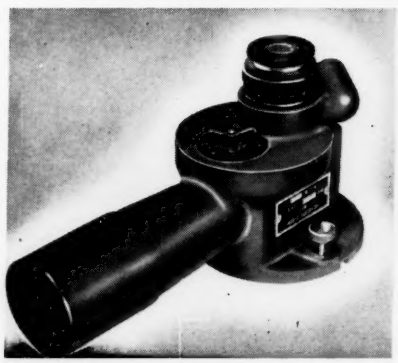
$200 VALUE FOR ONLY $12.50 POSTPAID

BIG 2" OBJECTIVE—KELLNER EYEPIECE—AMICI ERECTING PRISM

4 BUILT-IN FILTERS—RETICLE ILLUMINATION

This is Edmund's biggest bargain offer in an entire decade. Weight of this instrument is 5 pounds. Field is 6°, exit pupil is 0.243 inch. Excellent for finder on an astronomical telescope. Ideal for use as a mounted telescope for terrestrial observation. Also can be used for telephoto photography. Objective lens can be removed and a tube added with a longer focal length objective to convert to a high-power astronomical telescope. The focusing 28-mm. F.L. eyepiece alone is worth more than $12.50. These telescopes were designed for spotting airplanes in the sky and have excellent resolving power and definition. The image is sparkling clear and bright — will delight you. Adjustable focus from 15 feet to infinity. These instruments are in good condition — practically new. You can buy this exceptional bargain with absolute confidence. In accordance with the policy prevailing on all Edmund merchandise, we guarantee complete satisfaction or your money back.

Stock #70,065-Y **$12.50 ppd.**



M-70 3-POWER TELESCOPE

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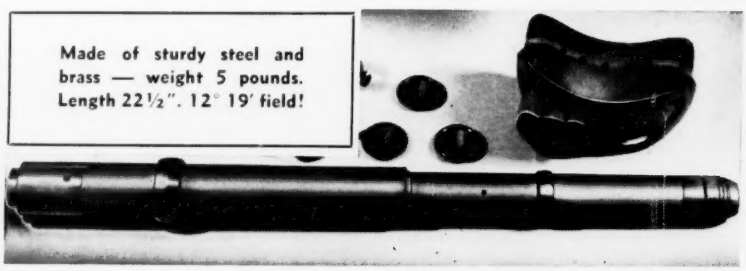

Another fine quality instrument throughout — produced by America's leading optical manufacturers. Telescope consists of a Kellner eyepiece, reticle, 2 achromatic lenses, 1 achromatic objective lens (25-mm. diam.), and a protective window. All optics are low-reflection coated. Also included: a rubber eyeguard, and amber, red, and neutral filters for snapping on to eyepiece. All these telescopes equipped with small window through which reticle can be illuminated with small flashlight.

By removing 3 screws, you can separate scope into 2 pieces, one of which makes an excellent 6-power finder for an astronomical telescope on which reticle can be illuminated for night use. To give you some idea of the intrinsic value you are getting here — as surplus, the lenses alone would cost double the price we are asking for the entire instrument. Bear in mind, too, that the eyepiece by itself can be used for an astronomical telescope.

Stock #80,055-Y **Completely boxed with protective absorbent, exactly as received from Army (new or near new)** **$7.50 ppd.**

Stock #80,051-Y **Telescope only (used—good condition)** **$4.00 ppd.**

THE MOUNTING RINGS FROM OUR STANDARD 7-POWER FINDER CAN BE USED ON THE ABOVE M-70 TELESCOPE

Stock #50,075-Y **Ring mounts per pair** **$4.95 ppd.**

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Achromatic Astronomical Telescope Objectives

Real Quality at Bargain Prices Make Wonderful Refractors

For three years we checked U.S., German, and Japanese manufacturers looking for one who could produce really good telescope objectives at a low price. A few times we ordered samples, only to be disappointed in quality or final price. Finally, we found a Japanese optical engineer who designed some excellent astronomical objectives. We place orders with him. He then has these made, checking each one for quality. Thus, we are able to offer objectives we believe to be as good as those selling for two or three times our price.

Our 3" and 4" diameter objectives are air-spaced achromats, as air-spacing gives the lens designer four surfaces with which to correct aberrations, instead of only three as in a cemented achromat. The results are a beautiful, color-free image, sharp, clear, with very flat field, and no bad zones.

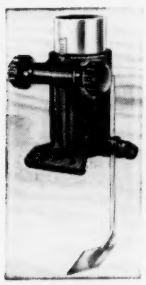
Stock No.	Diam.	F.L.	Price	Comments
30,166-Y	3"	45"	$28.00	Not coated
30,190-Y	3"	45"	32.00	Coated
50,106-Y	4"	60"	60.00	Not coated
50,107-Y	4"	60"	69.00	Coated on four surfaces

Metal cells are available for the objectives above.
Stock #70,063-Y.....$11.95 for 4" objective
Stock #70,064-Y.....$10.95 for 3" objective

LOW COST, LONG F.L. ACHROMAT

Stock #30,187-Y 50" F.L., 2" diam., coated $12.50 ppd.

Rack & Pinion Eyepiece Mounts



For Reflectors

For Refractors

Now you can improve performance in a most important part of your telescope — the eyepiece holder. Smooth, trouble-free focusing will help you to get professional performance. Look at all these fine features: real rack-and-pinion focusing with variable tension adjustment; tube accommodates standard 1¼" eyepieces and accessory equipment; lightweight aluminum body casting; focusing tube and rack of chrome-plated brass; body finished in black wrinkle paint. No. 50,077-Y is for reflecting telescopes, has focus travel of over 2", and is made to fit any diameter or type tubing by attaching through small holes in the base. Nos. 50,103-Y and 50,108-Y are for refractors and have focus travel of over 4". Will fit our 2⅞" I.D. and our 3⅞" I.D. aluminum tubes respectively.

Stock #50,077-Y (less diagonal holder) $9.95 ppd.
Stock #60,035-Y (diagonal holder only) 1.00 ppd.
Stock #50,103-Y (for 2⅞" I.D. tubing) 12.95 ppd.
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Here are some really terrific values in eyepieces! The three eyepieces listed below are manufactured by one of the world's best producers of optical components. We have searched the world's markets, including Germany and France, to find a real quality eyepiece. The image clarity, the workmanship evidenced in the metal parts, will prove the skill and experience of Goto Optical Company, Tokyo. Guaranteed terrific buys!

HUYGENS TYPE — STANDARD 1¼" DIAM.
6 mm. (¼") Focal Length
Stock #30,063-Y ..... $8.50 ppd.

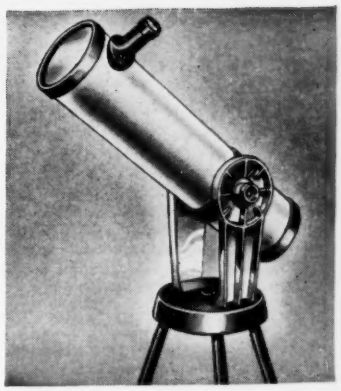
12.5 mm. (½") Focal Length
Stock #30,064-Y ..... $8.00 ppd.

COMBINATION EYEPIECE — 10 mm. and 20 mm.
Stock #30,065-Y ..... $9.00 ppd.

SPITZ MOONSCOPE

See the Earth's Satellite

A precision-made 32-power reflecting telescope — by makers of Spitz Jr. Planetarium. Clearly reveals the craters of the moon, shows Saturn, Jupiter, other wonders of the heavens. Based on same principles as world's giant telescopes. Stands 36" high on removable legs. Adjustable 3" polished and corrected mirror. Fork-type alt-azimuth mount rotates on full 360° circle—swings to any location in the sky. Fascinating 18-page instruction book is included. Instrument packed in sturdy carrying case.



Stock #70,068-Y ..... $14.95 ppd.

7X — FINDER TELESCOPE — ACHROMATIC
Stock #50,080-Y Finder alone, less ring mounts $9.95
Stock #50,075-Y Ring mounts per pr., $4.95

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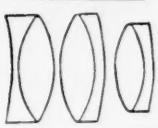
Stock No.	I.D.	O.D.	Lgth.	Description	Price
80,038-Y	47⁄8"	5¼"	16"	Spiral-wound paper	$2.50
85,008-Y	7"	7½"	60"		4.00
85,011-Y	27⁄8"	3"	48"	Aluminum	6.00
85,012-Y	37⁄8"	4"	60"		8.75
85,013-Y	47⁄8"	5"	48"		9.00
85,014-Y	67⁄8"	7"	60"		15.00

All tubing is shipped f.o.b. Barrington, N. J.



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68° FIELD OF VIEW

Consists of 3 coated achromats in metal mount with spiral focusing. F.L. 1¼". Diam. 54 mm., length 54 mm. War surplus. Govt. cost about $8.00. This is the type war-surplus bargain that will be talked about in years to come. Buy while you can.

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Provides 1¼" diameter mount for fitting above Erfle eyepiece into standard eyepiece holders.

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1¼" diam.

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DOUBLE AND TRIPLE YOUR TELESCOPE'S POWER WITH A BARLOW LENS

Stock #30,175-Y. Unmounted, O.D. 1-3/16". Coated. Fits in tubing listed below ..... $3.00 ppd.

Stock #30,140-Y. Mounted Achromatic Barlow Lens ..... $15.00 ppd.

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The same fine mirror as used in our Palomar, Jr., polished and aluminized, lenses for eyepieces and diagonal. No metal parts.

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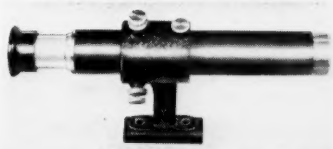
Stock #80,040-Y Fresnel Lens, size 11¾" x 16½"—f.l. 19" ..... $3.50 ppd.

Stock #40,067-Y First Surface Mirror, size 8" x 10" ..... $5.50 ppd.

5X FINDER TELESCOPE



Has crosshairs for exact locating. You focus by sliding objective mount in and out. Base fits any diameter tube—an important advantage. Has 3 centering screws for aligning with main telescope. 20-mm. diam. objective. Weighs less than ½ pound.

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KELLNER EYEPIECE — 2" focal length (1¼" O.D.). Mount of black anodized aluminum.

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60° SPECTROMETER PRISM — Polished surfaces 18 mm. x 30 mm. — flat to ½ wave length.

Stock #30,143-Y ..... $8.25 ppd.

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SYMMETRICAL EYEPIECE SETS. Finest quality. Consists of 3 standard-size oculars (focal lengths ½", ¾", 1¼") with prism star diagonal and Barlow lens attachment.
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TELESCOPE MIRRORS

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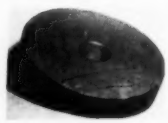
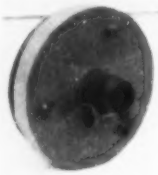


6-inch diam. ...$45.00 8-inch diam. ...$65.00



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5-INCH REFRACTOR
With Tripod

Consists of finest quality air-spaced objective, 75-inch focal length (f/15), corrected to 0.7 second of arc. Has high- and low-power finders, sturdy equatorial mounting with setting circles, adaptable to your powered drive. Matched set of three eyepieces, ½" to 1¼" focal lengths; star diagonal with Barlow lens attachment; rack-and-pinion focus.

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5-INCH REFRACTOR KIT

Contains identical high-quality optics and attachments as listed directly above, including aluminum tube. Detailed instructions for assembly and construction of light baffles, counterweights, and so forth. This is for you, if you are a handy man or woman!
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ZEISS 12-INCH APOCHROMATIC REFRACTOR. This unsurpassed Zeiss triplet is being replaced by a larger instrument after many years of excellent service at one of the West's leading universities. Its color-free lens is f/16; the mounting and drive are by Warner and Swasey. With attachments, including photographic equipment and spectrometer. Price, $22,500; details and photos on request.

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OBSERVER'S PAGE

Universal time is used unless otherwise noted.

Astrophotography for the Amateur — IV

When this series of articles began in January, I stated that objects of the third and fourth groups required guiding, since for them the plate scale is large and the exposures are often rather long.

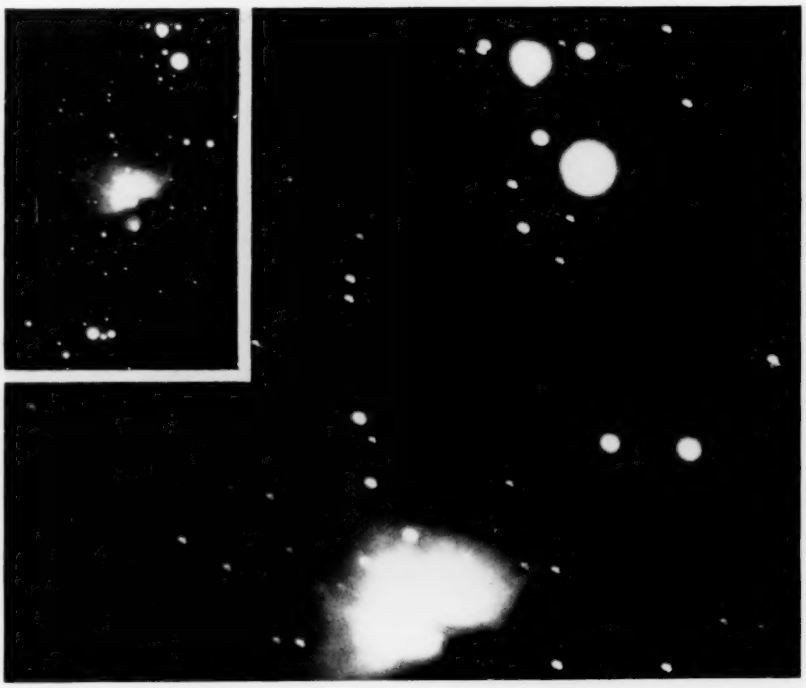
It is possible to use the telescope's finder for guiding, particularly if a Barlow lens is added to increase its power. But a regular guide telescope, with a focal length nearly the same as that of the lens that is making the picture, is far more satisfactory. One has now been added to my 5½-inch refractor, and it is used in conjunction with a novel slow-motion control that operates directly on the body of the prime-focus camera rather than on the driving mechanism of the telescope. These attachments will be described in this concluding article.

The guiding telescope is tubeless. Its objective is a 4-inch plano-convex lens of 65" focal length that cost only $4.75. This glass is mounted in a 5" square of ¼" aluminum plate, which is held in the telescope's front dovetail bracket otherwise used for the small cameras described in previous installments. The picture shows the very light dewcap of thin aluminum sheet, here partially shoved into place over the lens cell. A piece of Scotch tape holds the lens lock-ring in place.

The lower part of the guide telescope has a Goodwin Barlow unit (for 200x) in a hard rubber block which can slide, by rack-and-pinion motion, on an aluminum plate attached by a strap to the camera barrel. This sliding motion is toward and away from the optical axis, so the eyepiece position can be adjusted for guiding on a star some distance away from the object being photographed. The entire unit can be rotated around the camera barrel.

In January, I pointed out that a good sidereal drive is essential if a telescope is to be used in all-around celestial photography. Unguided pictures like this one of Orion's sword will reveal imperfections in the guiding system. Printed to a small scale (upper left) the photograph may seem acceptable, but when enlarged to show the details in the faint images it is obviously imperfect. In my case, the trouble was all in the eccentricity of the worm that transmits the power from the driving clock to the polar axis.

This worm is hardened, ground, polished, and has a key way, but I use no key, depending upon a tight push fit. Perhaps the key way causes distortion—a worm without a key way would have to be specially made. There are two universal joints between the clock and the worm, but one at the clock is sufficient

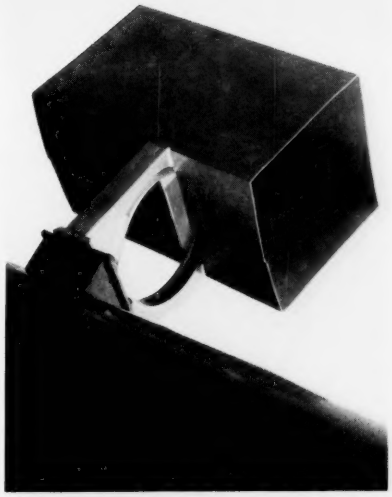


This picture of Orion's sword was made at the prime focus on January 18, 1956, an unguided exposure of 54 minutes, representing three turns of the driving worm of the 5½-inch refractor. A print nearly contact size (upper left) has fairly acceptable images, but enlargement to about 3½ times reveals their faults.

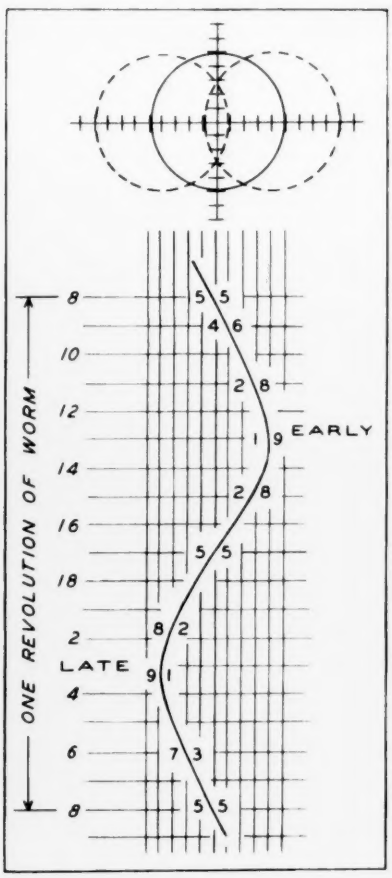
to provide a means for compensating an eccentric worm.

To test the worm for eccentricity, a shellacked cardboard disk was attached to the end of the shaft that protrudes beyond the worm. Since the worm requires 18 minutes to rotate once, I marked 18 divisions on the entire circumference of this disk, making it into a kind of clock that indicated what portion of the worm was engaging the worm gear at any particular position of the telescope.

Next, a bright star's image was placed somewhat out-of-focus on the reticle. Assume that the expanded image occupied 10 divisions of the reticle scale, five on each side of the central line when the image was centered. The diagram indicates what happened during the next 18 minutes as observed in the guiding eyepiece and recorded from the numbers on the dial attached to the axis of the worm. First the telescope ran fast, then slow, and the star image drifted until 9/10 of it was to one side of the central line; later it was as far out of position in the opposite direction. The trouble was easily corrected by placing a shim under the clock housing in the right place to introduce a sine condition at the universal joint; this counterbalances the eccentricity of the worm.



The nonachromatic objective of the Pfleumer guide telescope is attached to the upper end of the 5½-inch refractor, and has a square dewcap.



The full circle marks the mean position of the star image centered on the crosshairs of the reticle; the dashed circles show the extremes to which the image moved during the observations. The sine fluctuation in the star-image position matched one revolution of the worm.

The large picture on page 280 shows my guiding device, which operates directly on the camera, but in right ascension only. If correction in declination is necessary, the shutter is closed and the telescope moved by its slow motion into the correct position. The base of the guiding device is not shown in the picture; it consists of a steel pipe held upright in a heavy base plate. Inside the steel pipe slides a wooden post, adjustable up and down 15", to accommodate all positions of the telescope.

To the top or square section of the wooden post is pivoted a ⅜" rod, each half of which carries a weight that can slide along it. This is the balance rod, and the rate of driving is controlled by the observer shifting the weights along this rod. To the ends of the rod are attached wire or yarn (the latter is best

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Minor Axis	
¾"	$3.75
1"	3.75
1¼"	5.00
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MODIFIED RAMSDEN EYEPIECES

½", ¾", 1¼", 2", 3", and 4" focal lengths.
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VERY FINEST WASHED ROUGE for the final stages of polishing and figuring.
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It has been sold for more than 16 years and now is on display in at least two U. S. planetaria. It will show mountains and craters on the moon, Saturn's rings, Jupiter's four moons and the planet's markings, and close double stars with guaranteed observatory clearness. Skyscope enjoys worldwide distribution.

Every instrument, with its ¼-wave, aluminized mirror, is individually tested before being packed for shipment. We suggest that before buying you inquire at almost any local astronomy society about the efficiency of Skyscope. *100% American-made.*

We invite your attention to our free and straightforward descriptive brochure which also shows a photograph of the individual parts used.

125-power and 35-power extra eyepieces	$5.15 each
Six-power finder, with brackets	$7.50
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8"	1½"	$17.00
10"	1¾"	$29.95
12½"	2⅛"	$52.95

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Our newly designed Ramsden eyepieces, finely corrected, are constructed of selected brass stock, machined and fitted with utmost care. Body tube is hard chrome plated for wear resistance and cap is coated with baked black enamel. ¼", ½", ¾", 1", and 1½" focal length. **$9.50 each**

Kellner eyepieces, ¼" f.l., **$16**; ⅓", **$15**; ½", **$15**; ¾", **$18**; 1", **$18**

Orthoscopic, our best eyepieces, made on special order only, in ⅓", ⅔", and 1" focal length. **$20 each**

LABORATORY OPTICAL CO.

Plainfield, New Jersey

Available separately!

LUNAR MAP

To meet the unexpected demand, the LUNAR MAP, which appeared in the January issue, is now available separately. Over 10 inches in diameter, the map identifies all important features on the moon, including 326 mountains, valleys, and craters. A finding list of lunar place names is included. Ideal for framing, use at the telescope, studying, or in the classroom.

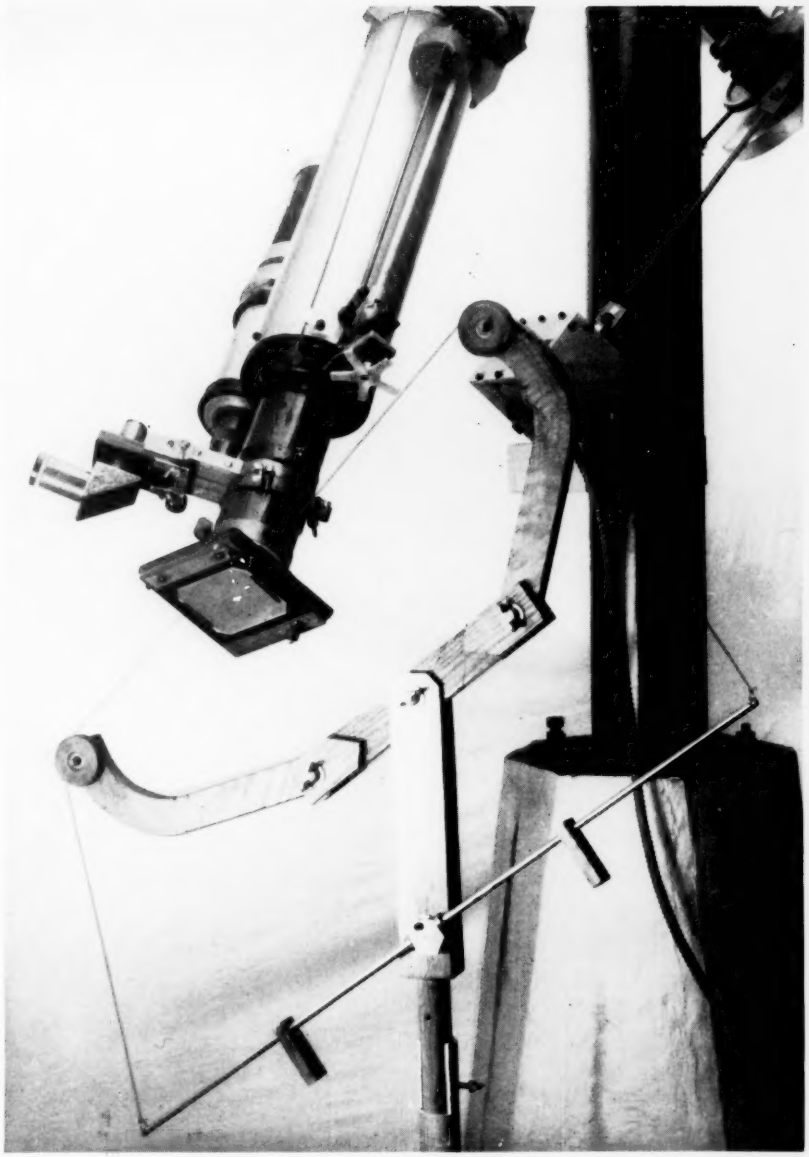
25 cents each, postpaid

3 or more, **20 cents each,** postpaid

Quantity orders: 100 or more, 10 cents each, plus postage. Special bulk quantity rates to planetariums and museums for counter sales.

SKY PUBLISHING CORPORATION

Harvard Observatory, Cambridge 38, Mass.



Attached to the lower end of the refractor is the prime-focus camera, with the ground glass for focusing clipped into place. To the left is the lower part of the guide telescope, with a 90° prism. In the upper right may be seen the two universal joints on the shaft from the clock drive to the polar axis. In the foreground is the balanced-rod slow-motion control that is adjusted by the observer to obtain the correct following rate.

for photography) which runs up to the camera body over two ball-bearing idlers or pulleys. The distance between the idlers can be changed and made large enough for long exposures, and the idler support arms are pivoted so they may be set in any required position. As the telescope swings in right ascension, it moves exactly between the idlers; care must be taken that the taut yarn does not pull the instrument off in declination.

It is advisable to make oneself as comfortable as possible for guiding during a long exposure. I find that a piano stool is perfect for refractor work if its seat can be screwed up and down. Also useful is a wrist watch that can be read in the dark. The aim of guiding is to keep the guide star as nearly centered on the reticle of crosshairs as possible, but changing the rate of drive or position of the image continuously may not be desirable. Watch the way the image drifts and try to adjust the driving rate at regular intervals until the most uniform results are obtained. Care should be taken in resetting the image not to overshoot the mark and produce additional blurring through too zealous correcting.

HANS PFLEUMER

596 First Ave.

New Brunswick, N. J.

Is there someone who hasn't written for UNITRON's New Catalog?

Eleven UNITRON Refractors To Choose From!

1.6" ALTAZIMUTH ($19 Down) **$75**
with eyepieces for 78x, 56x, 39x

2.4" MODELS—see page 264

3" ALTAZIMUTH ($66 Down) **$265**
with eyepieces for 171x, 131x, 96x, 67x, 48x

3" EQUATORIAL ($108 Down) **$435**
with eyepieces for 200x, 131x, 96x, 67x, 48x

3" PHOTO-EQUATORIAL ($137 Down) **$550**
with eyepieces for 200x, 171x, 131x, 96x, 67x, 48x

4" ALTAZIMUTH ($116 Down) with **$465**
eyepieces for 250x, 214x, 167x, 120x, 83x, 60x

4" EQUATORIAL ($196 Down) with **$785**
eyepieces for 250x, 214x, 167x, 120x, 83x, 60x, 38x

4" PHOTO-EQUATORIAL ($222 Down) **$890**
with eyepieces for 250x, 214x, 167x, 120x, 83x, 60x, 38x

4" PHOTO-EQUATORIAL with clock **$1175**
drive and astro-camera ($294 Down) with eyepieces for 250x, 214x, 167x, 120x, 83x, 60x, 38x, 25x

4" PHOTO-EQUATORIAL with clock **$1280**
drive, fixed pier, astro-camera ($320 Down) with eyepieces for 375x, 250x, 214x, 167x, 120x, 83x, 60x, 38x, 25x

Prices include tripod, mounting, and standard accessories. Additional eyepieces and accessories available for all models.

Use Our EASY PAYMENT PLAN

The UNITRON Easy Payment Plan is a convenient and economical way to buy your UNITRON Refractor when you do not want to disturb your savings or when you haven't the total cost of the telescope immediately available. The down payment required is 25%. The balance due is payable over a 12-month period, and there is a 6% carrying charge on the unpaid balance. Your first payment is not due until 30 days after you receive the instrument, and if you should want to pay the entire balance due at that time, the carrying charge is canceled.

HOW TO ORDER

Send check or money order in full or use our Easy Payment Plan, as described above. Shipments made express collect. Send 20% deposit for C.O.D. shipment. All instruments fully guaranteed.

UNIHEX ROTARY EYEPIECE SELECTOR: The old-fashioned method of fumbling with eyepieces in the dark has been outmoded by UNIHEX, UNITRON's new Rotary Eyepiece Selector. With UNIHEX, you always have 6 magnifications ready at your fingertips. To change power, merely rotate a new eyepiece into position while the object stays centered and in focus in the field of view. If through inaccurate tracking you should lose the object under observation, you need only rotate the lowest power eyepiece into position to convert your telescope into a giant view finder, recenter the object in the field of view and rotate back to the higher powers. Model A is designed to fit the UNITRON rack and pinion and is for UNITRONS only. Model B fits 1¼" eyepiece holders. Complete with special clamping device and cabinet.

Model A or B **Only $24.75 postpaid**

VIEW FINDER (As used on UNITRON 2.4" Equatorial): 23.5-mm. (.93") achromatic objective, 6x eyepiece with crosshairs. Chromed brass tube. Mounting brackets with centering screws.

Only $8.50 postpaid

VIEW FINDER (As used on UNITRON 3" Altazimuth): 30-mm. (1.2") coated achromatic objective and 8x eyepiece with crosshairs. Other details as in view finder described at the right.

Only $10.75 postpaid

An astronomical telescope gives an inverted image. For celestial observation this is not especially inconvenient, but for observing objects on land it is necessary to use an erecting prism system to re-invert the image or else stand on your head.

Designed with eighteen objective selectors, the UNIHEX Rotary Eyepiece Selector is the finest time saver ever invented. Instantly view through the finest-quality eyepiece in the UNIHEX Rotary Eyepiece Selector, and bring the right eyepiece to your eye.

Now all of the above is quite elementary and well known — except to those who are new to astronomy and have had no actual experience with a telescope. Such novices, in particular, will welcome the descriptions and illustrations of accessories such as the erecting prism system, star diagonal, UNIHEX, astro-camera, DUETRON, sun-projecting screen, etc., which are found in the new UNITRON Catalog and Observers Guide.

Articles of interest to all observers, whatever their degree of sophistication, include the constellations; observing the moon, sun, and planets; deep-sky wonders; amateur clubs and research programs; observing hints; how to choose a telescope; and a glossary of telescope and observing terms.

When the new catalog was being planned, it was found that some space would remain after the aforementioned articles. A UNITRON staff member offered the novel suggestion that we include illustrations and prices on all UNITRON Refractors and Accessories — and this was done. If you are considering the purchase of a telescope, or an accessory to modernize your present telescope, you will find this section of interest.

There is no charge for the new UNITRON Catalog and Observers Guide, so write, wire, or phone for your copy at once. (This free offer is limited to residents of the Solar System.)

RACK-AND-PINION FOCUSING MECHANISMS: Finest quality, as used in UNITRON Refractors. Shown above, left to right, **Standard, De Luxe,** and **Super** Models. Prices include long drawtube with eyepiece holders for both 24.5-mm. and 1¼" O.D. eyepieces. The Super Model can, in addition, hold our 60-mm. f.l., 58-mm. O.D. eyepiece. Standard and De Luxe Models have locks for the drawtube and focusing sleeve. Shipped postpaid.

Standard Model **Only $12.50**

De Luxe Model **Only $28.50**

Super Model **Only $44.50**

Couplings have outside diameter 2-9/16". For coupling to fit 3-1/16" I.D., add $3.00. For heavy coupling (which also acts as counterbalance) for 4⅜" O.D., add $9.50. Mounting screws included with all couplings.

VIEW FINDER (As used on UNITRON 4" Refractor): 42-mm. (1.6") coated achromatic air-spaced objective. 10x eyepiece with crosshairs. Duraluminum tube finished in white enamel. Dew-cap. Furnished with mounting brackets with centering screws for collimation. This finder also makes an excellent hand telescope for spectacular wide-field views of the sky.

Only $18.00 postpaid

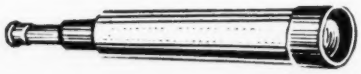
ASTRO-CAMERA 220: With this camera, owners of UNITRON altazimuth models can photograph the sun, sunspots, the moon, and solar and lunar eclipses. An equatorial model is required for recording other celestial objects which need longer exposures, and the clock drive is essential for prolonged tracking. The camera uses an air-operated curtain shutter of the Thornton-Pickard type, giving speeds of 1/10 to 1/90 second in addition to bulb and time. The camera may be positioned so that the plane of the film passes through the focal point of the objective, which is then the only optical element. When magnification of the primary image is desired, an eyepiece can be inserted into the camera tube and an image projected on the film. Astro-Camera 220 comes complete with ground-glass back, 3 double plate-holders for 3¼" x 4¼" plates or cut film, a 30-mm. f.l. eyepiece, extension tubes and clamps to lock the camera firmly in place, air-operated bulb release, removable filter, and a fitted wooden cabinet. Model A is designed to fit the UNITRON rack and pinion replacing the customary drawtube and is for UNITRONS only. Model B fits 1¼" eyepiece holders.

Model A or B **Only $69.50 postpaid**

See page 264 and the back cover.

UNITRON *Instrument Division* of UNITED SCIENTIFIC CO.
204-6 MILK ST., BOSTON 9, MASS.

"GIANT" 3-inch TELESCOPE



40 power

NEW! JUST OFF THE ASSEMBLY LINE!

Never before has anything like this been offered at so low a price. Here is another example of American ingenuity. Big 3" diameter achromatic coated objective which will give needle-sharp crystal-clear images. Focusing is a delight with the micrometer spiral focusing drawtube. Light-weight aluminum construction throughout, black crackle finish, length open 22 inches, closed 17 inches. This telescope gives an upright image — it is WONDERFUL for astronomy, SUPERB for long distances, EXCELLENT as a spotting scope.

A PERFECT GUIDE TELESCOPE.....Special Price **$57.50**

Aluminum Telescope Tubing

O.D.	I.D.	Price Per Ft.
2¼"	2⅛"	$1.20
3⅜"	3¼"	1.75
4½"	4⅜"	2.75
5"	4⅞"	2.75

All tubing is shipped POSTPAID

Focusing Eyepiece Mounts Rack & Pinion Type

The aluminum body casting is finished in black crackle paint and is machined to fit all our aluminum tubing. Has a chrome-plated brass focusing tube, which accommodates standard 1¼" eyepieces.

For 2⅛" I.D. Tubing	Postpaid	$12.95
For 3¼" I.D. Tubing	"	12.95
For 4⅜" I.D. Tubing	"	12.95

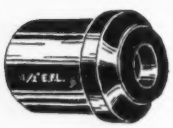
Reflector type for all size tubing

Complete with diagonal holder.....$ 9.95

Aluminum Lens Cells Black Anodized

Cell for Lenses	Cell Fits Tubing	Price
54 mm Diam.	2⅛" I.D.	$ 3.50
78 mm "	3¼" "	6.50
81 mm "	3¼" "	6.50
83 mm "	3¼" "	6.50
110 mm "	4⅜" "	10.50

MOUNTED EYEPIECES



The buy of a lifetime at a terrific savings to you. Perfect war - surplus lenses mounted in black anodized standard aluminum 1¼" mounts.

F.L.	TYPE	PRICE
12.5 mm (½")	Symmetrical.....	$ 6.00
16 mm (⅝")	Erfle (wide angle)...	12.50
16 mm (⅝")	Triplet.....	12.50
18 mm (¾")	Symmetrical.....	6.00
22 mm (27/32")	Kellner.....	6.00
32 mm (1¼")	Orthoscopic.....	12.50
35 mm (1⅜")	Symmetrical.....	8.00
55 mm (2⅛")	Kellner.....	6.00

The above eyepieces can be supplied **COATED** at 75 cents each extra.

AN ECONOMICAL EYEPIECE

This mounted eyepiece has two perfect fluoride-coated lenses 29 mm in diameter. It is designed to give good eye relief. It has an effective focal length of 1¼" (8x). The eyepiece cell fits a 1¼" tube..... **$4.50**

"GIANT" WIDE-ANGLE EYEPIECE

Known among amateurs as the "Giant Jaegers," this is the finest wide-angle eyepiece ever made. It gives a flat field. It is mounted in a focusing cell. This is an Erfle eyepiece, 1½" effective focal length, with a clear aperture of 23/16". It may be used as a Kodachrome viewer, magnifying seven times.

$125.00 Value..... **$18.50**

BRAND NEW COATED 1¼" E.F.L. wide-angle eyepiece. Contains 3 perfect achromats.

Aperture is 13/16". (Illustrated) **$12.50**

LENS CLEANING TISSUE — Here is a wonderful Gov't. Surplus buy of Lens Paper which was made to the highest Gov't. standards and specifications.

500 sheets size 7½" x 11"..... **$1.00**

"MILLIONS" of Lenses, etc. Free Catalogue

We pay the POSTAGE — C.O.D.'s you pay postage. Satisfaction guaranteed or money refunded if merchandise returned within 30 days.

JAEGERS DOES IT AGAIN!!

MOUNTED ASTRONOMICAL TELESCOPE OBJECTIVE

Air-spaced — f/15

We offer the lowest priced, hand-corrected, precision, American-made astronomical objective, *mounted in a black anodized aluminum cell*. Our reputation has been established over the years as the most reliable source of high quality astronomical lenses.

"Those in the know" BUY FROM US BECAUSE:

1. Hand-corrected
2. Air-spaced
3. BLACK ANODIZED ALUMINUM CELL
4. Precision Mounted — Ready to Use
5. Color-corrected
6. 3¼" or 4⅛" CLEAR APERTURE f/15
7. 48" or 62" FOCAL LENGTH
8. Quality Can't Be Beat
9. Lowest Price
10. Fully Guaranteed

Each lens is thoroughly tested by us and is guaranteed to resolve two seconds of arc or better. They are corrected for the C and F lines (secondary chromatic aberration). The zonal spherical aberration and the chromatic variation of spherical aberration are negligible. The cell is machined to close tolerances so that it will fit directly over our standard aluminum tubing, eliminating any mounting problems.

3¼" diam., 48" f.l. (uncoated).. **$28.00** — Same as above with coating.... **$32.00**

4⅛" diam., 62" f.l. (uncoated).. **$60.00** — Same as above with coating.... **$69.00**

We can supply ALUMINUM TUBING for the above lenses.

"BIG" ACHROMATIC TELESCOPE OBJECTIVES

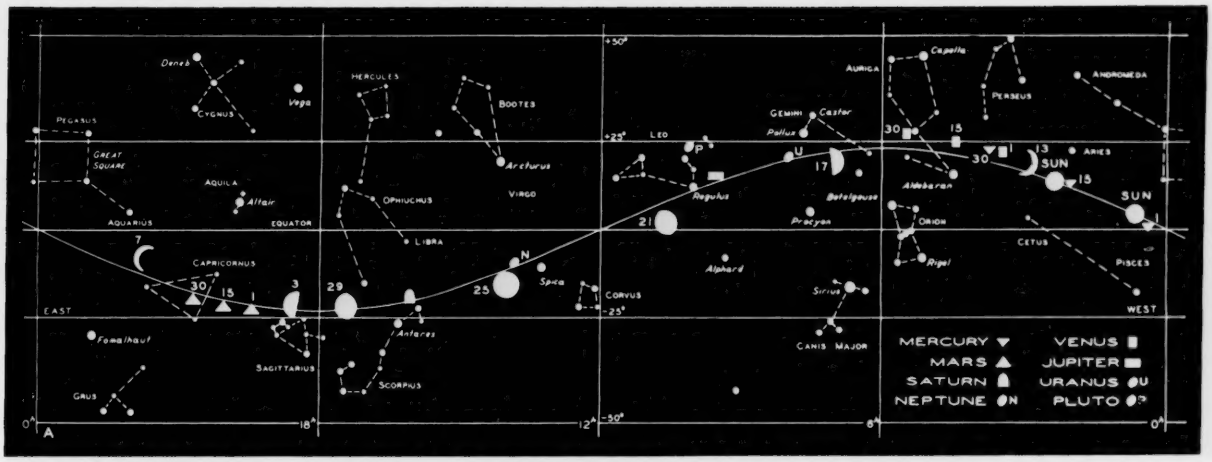
We have the largest selection of diameters and focal lengths in the United States available for immediate delivery. These are perfect magnesium-fluoride coated and cemented Gov't. surplus lenses made of finest crown and flint optical glass. Not mounted. Fully corrected. Tremendous resolving power. They can readily be used with eyepieces of only ¼" focal length, thereby producing high powers. Guaranteed well suited for astronomical telescopes, spotting scopes, and other instruments. Gov't. cost up to $100.

Diameter	Focal Length	Each	Diameter	Focal Length	Each
54 mm (2⅛")	254 mm (10")	$12.50	83 mm (3¼")	660 mm (26")	$28.00
54 mm (2⅛")	300 mm (11.8")	12.50	83 mm (3¼")	711 mm (28")	28.00
54 mm (2⅛")	330 mm (13")	12.50	83 mm (3¼")	762 mm (30")	28.00
54 mm (2⅛")	390 mm (15.4")	9.75	83 mm (3¼")	876 mm (34½") ...	28.00
54 mm (2⅛")	508 mm (20")	12.50	83 mm (3¼")	1016 mm (40")	30.00
54 mm (2⅛")	600 mm (23½") ...	12.50	102 mm (4")	876 mm (34½") ...	60.00
54 mm (2⅛")	762 mm (30")	12.50	108 mm (4¼")	914 mm (36")	60.00
54 mm (2⅛")	1016 mm (40")	12.50	110 mm (4⅜")*	1069 mm (42 1/16")	60.00
78 mm (3 1/16")	381 mm (15")	21.00	110 mm (4⅜")	1069 mm (42 1/16")	67.00
80 mm (3⅛")	495 mm (19½") ...	28.00	128 mm (5 1/16")*	628 mm (24¾") ...	75.00
81 mm (3 3/16")	622 mm (24½") ...	22.50	128 mm (5 1/16")	628 mm (24¾") ...	85.00

*Not coated

● We can supply ALUMINUM TUBING for the above lenses. ●

A. JAEGERS — **6918 Merrick Road, LYNBROOK, N. Y.**



THE SUN, MOON, AND PLANETS THIS MONTH

The sun, on the ecliptic, is shown for the beginning and end of the month. The moon's symbols give its phase roughly, with the date marked alongside. Each planet is located for the middle of the month and for other dates shown.

Mercury enters the evening sky on April 6th, and may first be viewed about the 15th. On that date, the planet sets one hour after the sun, and appears at magnitude −1.4. By the month's close, Mercury sets after twilight ends, but has faded to magnitude +0.2. Greatest elongation occurs on May 2nd, 20° 56′ east of the sun.

Venus attains greatest eastern elongation on April 12th, 45° 47′ from the sun. The planet sets four hours after the sun, and is visible as a brilliant white object in the western sky. Venus is in Taurus all month, and in the first days of April passes just south of the Pleiades. The magnitude of the planet on the 15th is −4.0, the telescopic disk being 24″ in diameter and 50-per-cent illuminated.

During April and May, Venus may be easily seen with the naked eye in the daytime, but low-power, wide-field binoculars will aid in locating it. Some observers may wish to apply the method for finding Venus by day described by Franklin Miller, Jr., in *Sky and Telescope*, August, 1954, page 353.

Mars arrives at western quadrature with the sun on April 29th, rising several hours before dawn. During April, the planet moves from Sagittarius into Capricornus. In midmonth it appears at magnitude +0.5, presenting a disk 8″ in diameter. (See page 257.)

Jupiter will be favorably placed for view during evening hours, a −1.8 magnitude object in midmonth, about 8° west of Regulus in Leo. Retrograde (westward) motion ends April 17th, when the Jovian disk is 40″.3 in equatorial diameter.

Saturn rises three hours after sunset in mid-April, and is visible for the rest of the night. Saturn is in slow retrograde motion, about 1½° north of Beta Scorpii, and appears at +0.4 magnitude. On the 15th, the ring system will be inclined 24°.5 to our line of sight.

Uranus comes to eastern quadrature with the sun on April 18th, and may be seen only during evening hours. Retrograde motion ends on the 5th, when Uranus is at right ascension 8h 01m.4, declination +21° 06′ (1950), in western Cancer.

Neptune is at opposition to the sun on April 19th, at a distance of 2,727 million miles from the earth. This slow-moving 8th-magnitude planet is about 7° east of Spica in Virgo, at 13h 50m.4, −9° 24′ (1950) on the date of opposition.

E. O.

OCCULTATION PREDICTIONS

April 14-15 **Iota Tauri** 4.7, 5:00.5 +21-31.7, 4, Im: **A** 1:45.7 −0.3 −1.1 83; **B** 1:42.2 −0.3 −1.0 77; **C** 1:48.8 −0.2 −1.3 97; **D** 1:42.1 −0.4 −1.2 87; **E** 1:41.9 −0.5 −1.7 109; **F** 2:00.4 +0.1 −3.4 150.

April 18-19 **Alpha Cancri** 4.3, 8:56.1 +12-01.8, 8, Im: **A** 0:46.9 −2.1 −0.3 87; **B** 0:44.3 −2.1 +0.1 79; **C** 0:39.4 −2.0 −0.7 104; **D** 0:32.6 −2.0 −0.2 93.

For stations in the United States and Canada, usually for stars of magnitude 5.0 or brighter, data from the *American Ephemeris* and the *British Nautical Almanac* are given here, as follows: evening-morning date, star name, magnitude, right ascension in hours and minutes, declination in degrees and minutes, moon's age in days, immersion or emersion; standard station designation, UT, **a** and **b** quantities in minutes, position angle on the moon's limb; the same data for each standard station westward.

The **a** and **b** quantities tabulated in each case are variations of standard-station predicted times per degree of longitude and of latitude, respectively, enabling computation of fairly accurate times for one's local station (long. **Lo**, lat. **L**) within 200 or 300 miles of a standard station (long. **LoS**, lat. **LS**). Multiply **a** by the difference in longitude (**Lo** − **LoS**), and multiply **b** by the difference in latitude (**L** − **LS**), with due regard to arithmetic signs, and add both results to (or subtract from, as the case may be) the standard-station predicted time to obtain time at the local station. Then convert the Universal time to your standard time.

Longitudes and latitudes of standard stations are:

A	+72°.5,	+42°.5	**E**	+91°.0,	+40°.0
B	+73°.6,	+45°.5	**F**	+98°.0,	+31°.0
C	+77°.1,	[illegible]	**G**	Discontinued	
D	+79°.4,	+43°.7	**H**	+120°.0,	+36°.0
			I	+123°.1,	+49°.5

SUNSPOT NUMBERS

January 1, 48, 54; **2**, 42, 49; **3**, 52, 44; **4**, 55, 38; **5**, 42, 49; **6**, 44, 47; **7**, 47, 52; **8**, 57, 52; **9**, 52, 52; **10**, 46, 32; **11**, 49, 38; **12**, 59, 35; **13**, 78, 78; **14**, 69, 80; **15**, 97, 90; **16**, 115, 118; **17**, 108, 126; **18**, 97, 127; **19**, 95, 128; **20**, 106, 120; **21**, 100, 110; **22**, 89, 100; **23**, 86, 91; **24**, 79, 87; **25**, 81, 103; **26**, 57, 69; **27**, 41, 48; **28**, 43, 45; **29**, 57, 43; **30**, 52, 45; **31**, 41, 36. Means for January: 67.2 American; 70.5 Zurich.

Above are given the date, the American number, then the Zurich number. These are observed mean relative sunspot numbers, the American computed by D. W. Rosebrugh from AAVSO Solar Division observations, the Zurich numbers from Zurich Observatory and its stations in Locarno and Arosa.

Read This Advertisement

Here is a combination of a Barlow and a particular ocular which gives outstanding results. It consists of our new Barlow and our 16.8-mm. (⅔″ focal length) Erfle eyepiece. While the Barlow was not specifically designed to work with this eyepiece, it does so to an astonishing degree. All images are sharp and hard to the very edge of the field.

The Barlow gives magnification up to slightly over three times that of the ocular alone. It is achromatic, coated, and mounted to the U. S. standard size of 1.250 inches.

The Erfle ocular has a field of approximately 68 degrees with excellent eye relief. The combination gives the equivalent focal length of slightly under 6 mm. Many users state it is far superior to any shorter focal length ocular of equivalent magnification.

The Barlow sells for $16.00 postpaid, and the Erfle for $14.75 postpaid. Both are guaranteed to perform as above stated or money refunded.

ORTHOSCOPIC OCULARS—All hard coated, standard 1¼-inch outside diameter.

28-mm.	**$15.00**	**10.5-mm.**	**$16.25**	**4-mm.**	**$17.25**
16.8-mm. (Erfle)	**$14.75**	**7-mm.**	**$17.25**	**Barlow 3x**	**$16.00**

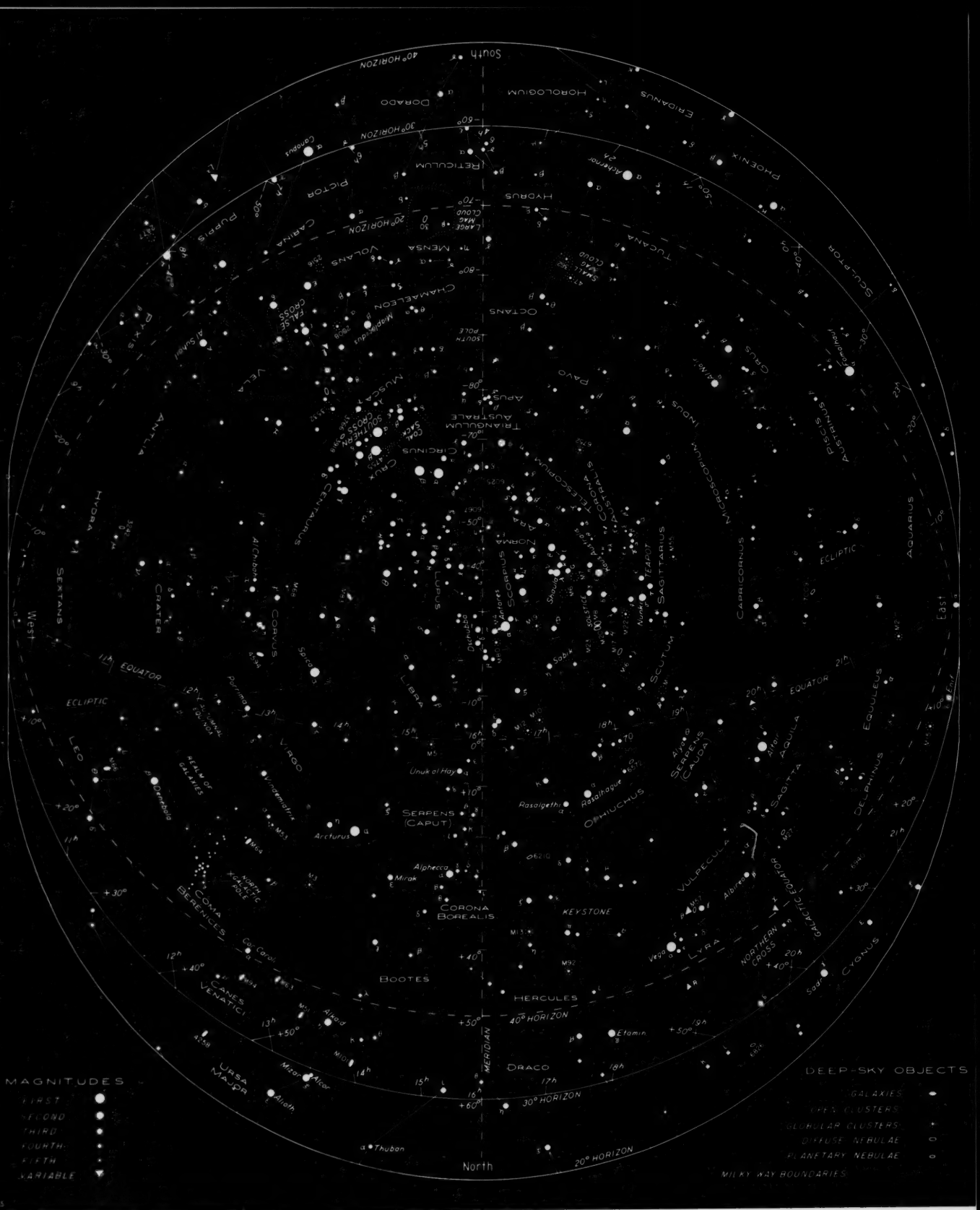
Warranted to equal or surpass any oculars obtainable anywhere or money refunded.

Finished mirrors, mirror kits, spiders, elliptical flats, focusing devices, aluminizing.

Send for catalogue.

Telescopics

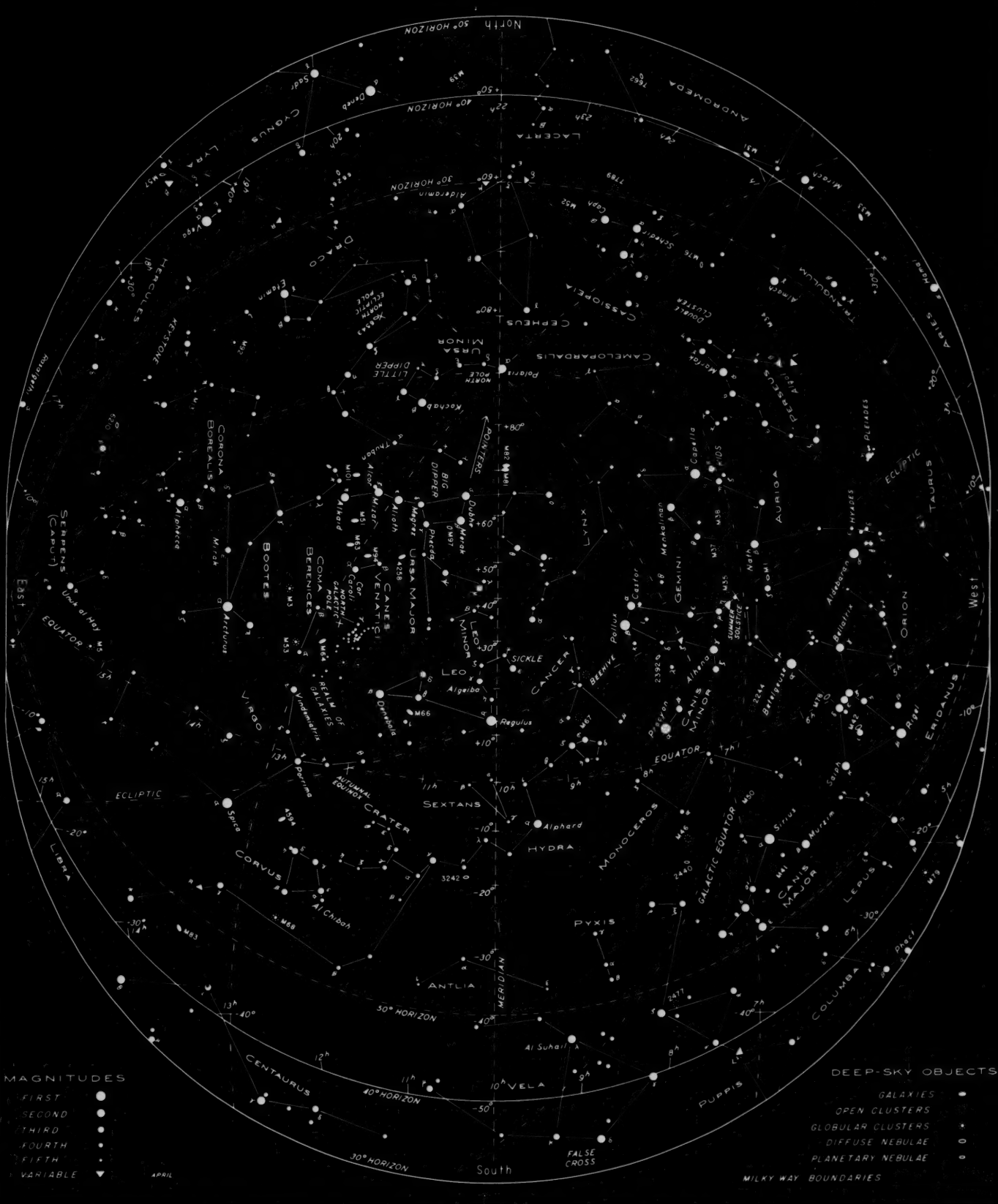
1000 North Seward Street
Los Angeles 38, Calif.



SOUTHERN STARS

The sky as seen from latitudes 20° to 40° south, at 9 p.m. and 8 p.m., local time, on the 7th and 23rd of July, respectively; also, at 7 p.m. and 6 p.m. on August 7th and 23rd. For other dates, add or subtract ½ hour per week.

At these times, the Milky Way is splendidly placed for Southern Hemisphere viewers, from Carina in the southwest, through Scorpius and Sagittarius nearly overhead, to Cygnus on the northeastern horizon. A moonless, very transparent night is best for the Milky Way.



STARS FOR APRIL

The sky as seen from latitudes 30° to 50° north, at 9 p.m. and 8 p.m., local time, on the 7th and 23rd of April, respectively; also, at 7 p.m. on May 7th. For other dates, add or subtract ½ hour per week.

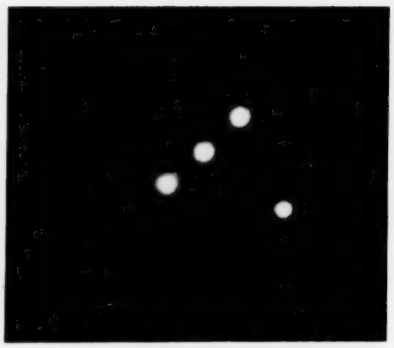
At chart time, an observer in latitude 40° north who has an unobstructed horizon can see 11 of the 1st-magnitude stars at once, as well as the bright planets Venus and Jupiter. Comparison of the colors of these 13 objects is an interesting naked-eye project.

JUPITER PASSING REGULUS

THREE NEGATIVES were printed as one to procure the accompanying picture showing the apparent motion of the planet Jupiter as it retrograded past the star Regulus in January. By matching stars at the opposite ends of the field, the negatives were superimposed in register; held together with cellophane tape they were then enlarged as one negative.

Jupiter's position is shown between 11 and 12 p.m. on the nights of January 20-21, 22-23, and 26-27, from lower left to upper right. The satellite close to the first image is III, while IV shows near the other two images of Jupiter. Each exposure was seven seconds, on Royal Pan film, not guided, with a 2.2-inch f/4.5 Bausch and Lomb aerial camera lens in a homemade mounting.

On the evening of January 27-28, Jupiter passed 42 minutes of arc north of Regulus, and its disk was 43 seconds of arc in diameter. The images of both star and planet are overexposed, so they appear large in comparison to the distance between them.



In six days during January, Jupiter appeared to move between the positions shown by the row of three images, past the star Regulus, at the right. Photograph by John Sanford.

JOHN SANFORD
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Newburgh, N. Y.

APRIL METEORS

Bright moonlight will greatly handicap observations of the Lyrid meteor shower in 1956. Its maximum activity will be on April 22nd, only three days before full moon. With no moon present, the predicted rate would be 12 meteors per hour, shortly before sunrise. The Lyrids radiate from 18h 12m, +31°, about 7° southwest of Vega. E. O.

VARIABLE STAR MAXIMA

April 4, RS Librae, 151822, 7.7; 4, V Ophiuchi, 162112, 7.5; 4, T Herculis, 180531, 8.0; 6, R Caeli, 043738, 8.0; 11, U Orionis, 054920a, 6.6; 13, R Cancri, 081112, 6.8; 16, L_2 Puppis, 071044, 3.4; 22, R Serpentis, 154615, 6.8; 23, V Cancri, 081617, 8.0; 25, V Monocerotis, 061702, 7.1; 27, X Monocerotis, 065208, 7.6; 29, R Bootis, 143227, 7.3; 29, RU Cygni, 213753, 8.0; 30, RV Centauri, 133155, 7.6; 30, V Cassiopeiae, 230759, 7.9.

These predictions of variable star maxima are by the AAVSO. Only stars are included whose mean maximum magnitudes are brighter than magnitude 8.0. Some, but not all of them, are nearly as bright as maximum two or three weeks before and after the dates for maximum. The data given include, in order, the day of the month near which the maximum should occur, the star name, the star designation number, which gives the rough right ascension (first four figures) and declination (bold face if southern), and the predicted magnitude.

MOON PHASES AND DISTANCE

Last quarter	April 3,	8:06
New moon	April 11,	2:39
First quarter	April 17,	23:28
Full moon	April 25,	1:40
Last quarter	May 3,	2:55

	April	Distance	Diameter
Apogee	3, 10h	251,100 mi.	29′ 34″
Perigee	15, 22h	220,300 mi.	32′ 23″
	May		
Apogee	1, 5h	251,300 mi.	29′ 33″

PREDICTIONS OF BRIGHT MINOR PLANET POSITIONS

Hebe, 6, 9.5. April 7, 14:36.0 +6-30; 17, 14:28.2 +7-18; 27, 14:19.5 +8-49. May 7, 14:10.7 +9-31; 17, 14:02.9 +9-50; 27, 13:56.6 +9-16.

Vesta, 4, 6.0. April 7, 14:41.6 −2-59; 17, 14:33.9 −2-08; 27, 14:21.8 −1-27. May 7, 14:15.3 −1-03; 17, 14:07.0 −0-59; 27, 14:00.9 −1-16. For a map of Vesta's path among the stars, see page 145, January issue.

After the asteroid's name are its number and the magnitude expected at opposition. At 10-day intervals are given its right ascension and declination (1950.0) for 0h Universal time. In each case the motion of the asteroid is retrograde. Data are supplied by the IAU Minor Planet Center at the University of Cincinnati Observatory.

MINIMA OF ALGOL

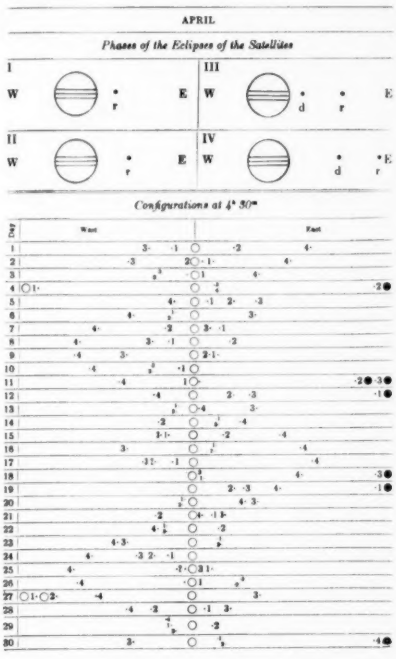
April 2, 5:34; 5, 2:24; 7, 23:13; 10, 20:02; 13, 16:51; 16, 13:40; 19, 10:29; 22, 7:18; 25, 4:07; 28, 0:57; 30, 21:46. May 3, 18:35; 6, 15:24; 9, 12:13; 12, 9:02.

These minima predictions for Algol are based on the formula in the 1953 *International Supplement* of the Krakow Observatory. The times given are geocentric; they can be compared directly with observed times of least brightness.

JUPITER'S SATELLITES

The configurations of Jupiter's four bright moons are shown below, as seen in an astronomical or inverting telescope, with north at the bottom and east at the right. In the upper part, *d* is the point of disappearance of the satellite in Jupiter's shadow; *r* is the point of reappearance.

In the lower section, the moons have the positions shown for the Universal time given. The motion of each satellite is from the dot toward the number designating it. Transits over Jupiter's disk are shown by open circles at the left, eclipses and occultations by black disks at the right. The chart is from the *American Ephemeris and Nautical Almanac*.



UNIVERSAL TIME (UT)

TIMES used on the Observer's Page are Greenwich civil or Universal time, unless otherwise noted. This is 24-hour time, from midnight to midnight; times greater than 12:00 are p.m. Subtract the following hours to convert to standard times in the United States: EST, 5; CST, 6; MST, 7; PST, 8. If necessary, add 24 hours to the UT before subtracting, in which case the result is your standard time on the day preceding the Greenwich date shown

SKY-GAZERS EXCHANGE

Classified advertising costs 15 cents a word, including address; minimum charge, $3.00 per ad. *Remittance must accompany order.* Insertion is guaranteed only on copy received by the 20th of the second month before publication; otherwise, insertion will be made in next issue. We cannot acknowledge classified ad orders. Sky Publishing Corporation assumes no responsibility for statements made in classified ads, nor for the quality of merchandise advertised. Write Ad Dept., Sky and Telescope, Harvard Observatory, Cambridge 38, Massachusetts.

FOR SALE: Tinsley 4″ portable refractor telescope with tripod. Achromatic objective, 60″ focal length. Accessories: wide-angle 6x finder, star diagonal, and 3 eyepieces (2″, ½″, and ¼″). $325.00. A. Cottone, 340 Canal St., New York, N. Y.

ECONOMICAL BUY: Kraft fiberboard telescope tubes for 6″ mirrors. Strong, durable, moisture-proofed. 3/16″ wall, 7″ inside diameter, 60″ length. Cut, drill, or saw it. $7.00 f.o.b. D. E. Fish, 2821 West 147 St., Gardena, Calif.

MOUNTED: 5″ and 6″ refractor objectives of first quality, $220.00 and $325.00. 4″ edged blanks, $20.00. Correspondence invited. Earl Witherspoon, Sumter, S. C.

FOR SALE: 8″ reflector, 79″ focal length. Perfect definition, sturdy mounting. With 8-mm., 16-mm., and 32-mm. oculars, up to 500x, $125.00 complete. Tom Wertenberger, 206 Henley Rd. South, Richmond, Ind.

SEAMLESS FIBERGLASS reinforced telescope tubes for 6″ and 8″ mirrors. Light weight, rigid strength and beauty. Painted, ready to mount. No dealers please. Write W. Parks, 16815 Faysmith, Torrance, Calif.

"TARGET: EARTH" is collision geology. This book presents and evaluates evidence of repeated collisions of large meteors with the earth. Authors — Allan O. Kelly and Frank Dachille. 263 pages, $5.00. Target: Earth, Box 335, Carlsbad, Calif.

FOR SALE: 8″ refractor, mounted, fork type on tripod. Offers wanted. Photos, details, from James Wyber, 4756 Myrtle St., Montebello, Calif.

EQUATORIAL MOUNTS. Axes 1¼″ cold-rolled steel, genuine Oilite bronze bearings; accurate setting circles, slow motion both axes, also can be moved independently of drives; latitude adjustment, and rotating tube saddle. 6″ model, only $100.00 f.o.b. Quality Optics, Walbridge, Ohio.

OPPORTUNITY KNOCKS once more: A 6″ Alvan Clark equatorial with all original accessories. Write for lists of telescopes and books. Rasmussen and Reece, Amsterdam, N. Y.

FOR SALE: 6″ reflector, mounted, finder, oculars, manual drives. Equatorial mountings for 3″ to 7″ tubes. John McQuaid, 2003 High St., Logansport, Ind.

NOW—THREE MORE POWERS AVAILABLE!

Brandon Orthoscopic Oculars

Above are examples of Brandon orthoscopic eyepieces, pictured in full size, with 1¼" diameter tubes.

YOU HAVE A CHOICE OF 7 POWERS!

In response to your many requests, we have added three new sizes to our series of orthoscopic eyepieces. They have effective focal lengths of 6, 12, and 24 millimeters, fitting perfectly into the original series of 4, 8, 16, and 32 millimeters. Thus you can choose from a series of 7 eyepieces, equivalent to the following in inches:

4-mm. . . . . 1/6" 6-mm. . . . . 1/4" 8-mm. . . . . 1/3" 12-mm. . . . . 1/2"
16-mm. . . . . 2/3" 24-mm. . . . . 1" 32-mm. . . . . 1-1/3"

The range of powers now available, using the finest oculars we can produce, is well demonstrated with a standard 6-inch, f/8 reflector, with a focal length of about 48 inches, for which our eyepiece series will give approximately:

4-mm. . . . . **300x** 6-mm. . . . . **200x** 8-mm. . . . . **150x** 12-mm. **100x**
16-mm. . . . . **75x** 24-mm. . . . . **50x** 32-mm. **38x**

The painstaking care you put into your mirror or telescope can be nullified by an inferior eyepiece. Prototypes of the three new Brandon orthoscopic oculars have undergone exhaustive tests for the past two years, making our entire series what we believe to be the best available, regardless of price. Here are the specifications:

1. Four-element design giving a flat, beautifully corrected field of 50° covering more than 160 per cent of the area of the conventional Ramsden for the same power. This eyepiece is a "must" for RFT work.
2. Precision optical elements, magnesium fluoride hard coated, increasing the light transmission approximately 10 per cent.
3. Simple take-down for cleaning.
4. Precision metal parts black anodized for anti-reflection and ground to 1¼" O.D.
5. Clean mechanical design permitting comfortable observation and ease of focusing.

Order these eyepieces in 4-mm., 6-mm., 8-mm., 12-mm., 16-mm., 24-mm., and 32-mm. effective focal lengths.

$15.95 each, postpaid

Your order, accompanied by check or money order, will be filled immediately and sent airmail insured. Be sure to specify the sizes you desire. Satisfaction guaranteed, or your money will be refunded.

Brandon Instruments

GUAYNABO, PUERTO RICO

UNITRON Goes to the Theatre!

When we went to the theatre to see the UNITRON 4" Altazimuth Refractor appear in the Richard Rodgers and Oscar Hammerstein production, **Pipe Dream,** we weren't too well acquainted with the plot. We assumed that America's most distinguished musical team had finally come around to glorifying America's most famous refractors.

As we waited for the curtain to go up, we recalled the Rodgers and Hammerstein technique used in **Oklahoma!** and anticipated hearing Helen Traubel sing, "Oh, What a Beautiful UNITRON," followed by Judy Tyler's rendition of "The UNITRON with the Dewcap on Top." For some reason these arias failed to materialize. Instead the plot began to develop around the doings of a marine biologist and his microscope.

This was not **too** disappointing since, after all, microscopes for research and industry are a main part of our business — although we have a special soft spot in our hearts for telescopes — and any plug for a microscope is also a plug for UNITRON. But after a while, sure enough, the 4" UNITRON made its appearance, resplendent in a big red bow. You see it above surrounded by good company.

The **Pipe Dream** cast features, left to right, Rufus Smith (wearing hat), Mike Kellin, G. D. Wallace (holding hat), William Johnson (arm in sling), Judy Tyler, and Helen Traubel. This musical is now playing at the Shubert Theatre in New York and is a smash hit. Perhaps when it goes on tour, it will play in your vicinity. If so, you certainly won't want to miss it!

See pages 264 and 281.

UNITRON *Instrument Division* of UNITED SCIENTIFIC CO.
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